



Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA

DRAFT FINAL WORK PLAN

Parcel C Buildings 211 and 253 Radiological Remediation
HUNTERS POINT NAVAL SHIPYARD, SAN FRANCISCO, CA
August 2018

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DCN: GLBN-0005-0001-0015



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Prepared for:

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Naval Facilities Engineering Command Southwest
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Contract Number: N62473-17-D-0005; Task Order No. 0001

DCN: GLBN-0005-0001-0015



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**NAVAL FACILITIES ENGINEERING COMMAND SOUTHWEST
SAN DIEGO, CALIFORNIA**

**DRAFT WORK PLAN
PARCEL C BUILDINGS 211 AND 253 RADIOLOGICAL REMEDIATION
HUNTERS POINT NAVAL SHIPYARD
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EXECUTIVE SUMMARY

This work plan describes the radiological remediation and survey of Buildings 211 and 253 in Parcel C of the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California. The remediation and survey activities are designed to achieve radiological release to unrestricted use of the buildings, including the trenches excavated to remove the sanitary sewer and storm drain (SSSD) lines beneath and adjacent to the buildings. The *Final Hunters Point Shipyard Historical Radiological Assessment, Volume II, History of the Use of General Radioactive Materials, 1939–2003* (Naval Sea Systems Command [NAVSEA], 2004) provides a summary of radiological operations conducted in the buildings by the U.S. Department of the Navy (Navy), and identifies the radionuclides of concern as strontium (Sr)-90, cesium (Cs)-137, radium (Ra)-226, thorium (Th)-232, and plutonium (Pu)-239.

The removal/remediation activities include: (1) removal of contaminated material and equipment within the buildings, (2) remediation of surface-contaminated areas within the buildings, and (3) removal of SSSD lines beneath and within 15 feet (5 meters) of the buildings. In order to achieve the radiological release of Buildings 211 and 253 to unrestricted use, a series of surveys will be performed to identify or confirm the existence of contamination, identify further areas requiring follow-up, delineate the scope of remediation, guide remediation activities as they are performed, and confirm the success of the remediation.

Buildings 211 and 253 were divided into Class 1, Class 2, and Class 3 survey units in accordance with guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM; U.S. Department of Defense [DoD] et al., 2000). Four types of survey measurements will be collected: contiguous static measurements, smear samples, gamma scans, and volumetric samples. Survey results will be compared to the remediation goals established in Table 5 of the *Final Record of Decision for Parcel C, Hunters Point Shipyard, San Francisco, California* (Parcel C ROD; Navy, 2010). The comparison will be used to make decisions regarding data collection activities in the field (i.e., investigation, remediation, reclassification, and resurvey as described in Section 5.7).

Once compliance with the remediation goals is demonstrated, dose and risk modeling will be performed using the survey data to determine whether residual radioactivity, distinguishable from background, will result in a total effective dose equivalent (TEDE) less than or equal to 12 mrem/yr and an excess cancer risk between 10^{-4} to 10^{-6} to an average member of the critical group. The critical group is composed of the individuals reasonably expected to receive the greatest exposure to residual radioactivity.

A survey unit data package will be prepared for each building and excavated trench survey unit once remediation and survey activities are complete and survey and sampling data are assessed. The compiled data package will be submitted to the Navy for review and concurrence. The information will be summarized into a final status survey report that documents the suitability of each building and excavated trench for radiological release to unrestricted use. Lastly, a removal action completion report (RACR) will be prepared that documents the removal/remediation actions performed consistent with the Parcel C ROD (Navy, 2010).

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ABBREVIATIONS AND ACRONYMS

Ac	actinium
AHA	activity hazard analysis
ANL	Argonne National Laboratory
APP	Accident Prevention Plan
ARAR	applicable, relevant, and/or appropriate regulation
BCT	BRAC Closure Team
Bi	bismuth
BRAC	Base Realignment and Closure
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter(s)
cm ²	square centimeter(s)
cpm	counts per minute
Cs	cesium
CSO	Caretaker Site Office
DCP	<u>Dust Control Plan</u>
dpm	disintegrations per minute
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	<u>Department of Transportation</u>
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
EPP	<u>Environmental Protection Plan</u>
ERRG	Engineering/Remediation Resources Group
FCR	field change request
FSS	final status survey
Gilbane	Gilbane Federal
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	high efficiency particulate air
HPNS	Hunters Point Naval Shipyard
HRA	Historical Radiological Assessment
ISO	International Organization for Standardization
KCH	Kleinfelder CH2M Hill Joint Venture
LBGR	lower bound of gray region
LLRW	low-level radioactive waste
m	meter(s)
m ²	square meter(s)
m/sec	meters per second
M&E	material and equipment
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual

MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MeV	mega-electron volts
mg/cm ²	milligrams per square centimeter
mrem/yr	millirem per year
N/A	not applicable
NAD	North American Datum
NaI	sodium iodide
NAVSEA	Naval Sea Systems Command
Navy	U.S. Department of the Navy
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
OHP	California Office of Historic Preservation
OSWER	Office of Solid Waste and Emergency Response
Pb	lead
pCi/g	picocuries per gram
PM10	particulate matter less than 10 microns in diameter
Po	polonium
PPE	personal protective equipment
Pu	plutonium
QA	quality assurance
QC	quality control
Ra	radium
RACR	removal action completion report
RASO	NAVSEA Detachment Radiological Affairs Support Office
RCA	radiologically controlled area
ROD	Record of Decision
ROICC	Resident Officer in Charge of Construction
RMWMP	Radioactive Material and Waste Management Plan
Rn	radon
RPM	Remedial Project Manager
RPP	Radiation Protection Plan
RSI	Radiation Solutions, Inc.
RSY	radiological screening yard
SAP	Sampling and Analysis Plan
SFRA	San Francisco Redevelopment Agency
SSHHP	Site Safety and Health Plan
SSSD	sanitary sewer and storm drains
Sr	strontium
SUPR	survey unit project report
SWMP	Storm Water Management Plan
Th	thorium
TtEC	TetraTech EC, Inc.
U	uranium
UBGR	upper bound of gray region

DRAFT Work Plan
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UFGS United Facilities Guide Specification
USACE U.S. Army Corps of Engineers
Y yttrium

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1.0 INTRODUCTION

This work plan describes the radiological remediation and surveys to be performed of Buildings 211 and 253 in Parcel C of the former Hunters Point Naval Shipyard (HPNS) in San Francisco, California (Figure 1). This work plan was prepared by Gilbane Federal (Gilbane) for the U.S. Department of the Navy (Navy) Base Realignment and Closure (BRAC) Program Management Office West under Radiological Environmental Multiple Award Contract N62473-17-D-0005, Contract Task Order 0001, with the Naval Facilities Engineering Command Southwest.

1.1 SITE HISTORY AND DESCRIPTION

HPNS is located in southeastern San Francisco on a peninsula that extends east into San Francisco Bay. HPNS encompasses 866 acres: 420 acres on land and 446 acres under water in the San Francisco Bay. In 1940, the Navy obtained ownership of HPNS for shipbuilding, repair, and maintenance. After World War II, activities at HPNS shifted to submarine maintenance and repair. HPNS was also the site of the Naval Radiological Defense Laboratory. HPNS was deactivated in 1974 and remained relatively unused until 1976. Between 1976 and 1986, the Navy leased most of HPNS to Triple A Machine Shop, Inc., a private ship repair company. In 1987, the Navy resumed occupancy of HPNS. HPNS property was placed on the National Priorities List in 1989 pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Buildings 211 and 253 are located in Parcel C. Composed of about 73 acres in the central portion of the shipyard, Parcel C was formerly part of the industrial support area, and was used for shipping, ship repair, and office and commercial activities. Industrial support facilities for ship repair dominated the land use at Parcel C and included a foundry, a power plant, a sheet metal fabrication shop, a paint shop, and various machine shops.

The *Final Record of Decision for Parcel C, Hunters Point Shipyard, San Francisco, California* (Parcel C ROD; Navy, 2010) shows Buildings 211 and 253 within Department of Defense (DoD) Installation Restoration Program Site 28 (IR-28). The non-radiological chemicals of concern associated with this site include metals, pesticides, polychlorinated biphenyls, polynuclear aromatic hydrocarbons, volatile organic compounds, semivolatile organic compounds, total oil and grease, and a variety of total petroleum hydrocarbons. The radionuclides of concern are

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strontium (Sr)-90, cesium (Cs)-137, radium (Ra)-226, thorium (Th)-232, and plutonium (Pu)-239.

1.2 PROJECT OBJECTIVE AND SCOPE

The project objective is to achieve the radiological release for unrestricted use of Buildings 211 and 253, including the trenches excavated to remove the remaining sanitary sewer and storm drain (SSSD) lines around the buildings that were left in-place during previous activities that removed the exterior portions of the SSSD lines. The remaining SSSD lines are shown on Figure 2. The project objective supports the remedial action objective for radiologically impacted soil and structures in Parcel C which, as stated in the Parcel C ROD (Navy, 2010), is to prevent or minimize exposure to radionuclides of concern in concentrations that exceed remediation goals for all potentially complete exposure pathways (for example, external radiation, soil ingestion, and inhalation of resuspended radionuclides in soil or dust).

For this project, the project scope consists of the following:

1. Conduct radiological surveys and perform remediation as necessary at Buildings 211 and 253, and
2. Remove the SSSD lines remaining ~~beneath inside and outside~~ within approximately 145 feet (5 meters [m]) of Buildings 211 and 253, and conduct radiological surveys and sampling of trenches ~~and soil~~ excavated to remove the SSSD lines.

Material and equipment (M&E) removed as a result of building remediation activities will be characterized and properly disposed as waste. M&E include metals, concrete, dispersible bulk materials, tools, equipment, piping, conduit, ductwork, fixtures, furniture, etc. that are considered non-real property distinguishable from buildings and land.

This work plan does not address chemical contamination except in relation to characterizing for disposal soil excavated during the removal of the SSSD lines.

1.3 REGULATORY FRAMEWORK

Environmental investigation and remediation activities are conducted at HPNS under the U.S. DoD Installation Restoration Program in accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan requirements in Title 40 Code of Federal Regulations, Part 300.415(b)(2). Under Executive Order 12580, the Navy is the lead agency

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responsible for implementation of the Installation Restoration Program and removal actions. Removal actions specific to Parcel C are presented in the Parcel C ROD (Navy, 2010).

The U.S. Environmental Protection Agency (EPA) is the lead regulatory agency. Additional regulatory oversight is provided by the Department of Toxic Substances Control (DTSC); the Regional Water Quality Control Board, San Francisco Bay Region; California Department of Public Health (CDPH), and other agencies.

Radiological remediation at HPNS is performed under Navy oversight with technical input from the Naval Sea Systems Command Detachment and Radiological Affairs Support Office (RASO), with review by the EPA and CDPH. RASO reviews work plans, provides technical input during the work process, reviews data packages, and concurs with waste material (e.g., excavated soil, contaminated M&E) disposition.

Navy policy requires the contractor performing radiological work to maintain independent license authority. Gilbane possesses current radioactive material licenses from the U.S. Nuclear Regulatory Commission (NRC; License No. 04-29358-01) and the State of California (License No. 7948-07). The NRC Region IV and the CDPH Radiologic Health Branch, respectively, provide federal and state regulatory oversight for license operations.

Gilbane will coordinate with the BRAC Remedial Project Manager (RPM), RASO, the Navy's Resident Officer in Charge of Construction (ROICC), the HPNS Caretaker Site Office (CSO), and the Navy's basewide low-level radioactive waste (LLRW) disposal contractor to ensure proper work oversight. This includes identifying, establishing, and maintaining temporary facilities for the storage and handling of radioactive material in its possession. The memorandum of understanding among radioactive material licensees working at HPNS will be revised to ensure proper interfacing of radioactive material handling responsibilities.

1.4 WORK CONTROL

This work plan presents the overall approach, requirements, and methods for executing the project scope and achieving the project objectives. It and its supporting plans described below are designed to protect workers, the public, and the environment. All plans will be available on site in hardcopy form. A project schedule is shown on Figure 3.

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Once approved by the Navy, changes to plans will require a field change request (FCR), which may include both text and figures based on the nature of the plan change. The Navy, with technical assistance from Gilbane, will coordinate FCRs with the regulatory agencies, as required, and provide notification of any other additional requirements to facilitate regulatory agency coordination.

1.4.1 Sampling and Analysis

Sampling and analysis activities will be performed according to the Sampling and Analysis Plan (SAP) provided in Appendix A. The SAP, prepared in the *Uniform Federal Policy for Quality Assurance Project Plans* (EPA et al, 2005) format, describes how sampling will be performed and details the laboratory operations that will support the sampling activities, including checks to ensure the quality of laboratory work performed.

1.4.2 Quality Assurance/Quality Control

Quality assurance (QA)/quality control (QC) will be performed according to the QA/QC Plan provided in Appendix B. The QA/QC Plan, prepared in accordance with United Facilities Guide Specification (UFGS)-01 45 00.00 20, *Quality Control* (UFGS, 2017b), describes:

- The QA/QC organization, including a chart showing lines of authority;
- The name, qualifications, duties, authorities, and responsibilities of each person assigned a QC function; and
- A schedule for managing submittals, testing, inspections, and other QA functions (including those of subcontractors, fabricators, suppliers, purchasing agents, etc.) that involve assuring quality workmanship, verifying compliance with the plans and specifications, and other QC objectives.

A QA surveillance plan with a list of definable features of the work was developed and will be implemented by conducting inspections to verify compliance with work elements and planning document requirements. Reporting includes summary reports of field work with corresponding site photos, a schedule of data submissions, inspection data sheets, problem identification and corrective measures reports, evaluation reports, acceptance reports, and final documentation.

1.4.3 Radioactive Materials and Waste Management

Radioactive materials and waste will be managed according to the Radioactive Materials and Waste Management Plan (RMWMP) in Appendix C. The RMWMP outlines the day-to-day

management of radioactive materials in support of the building remediation and SSSD line removal activities, including storage, transportation, and disposal of LLRW. Applicable regulatory requirements for waste management are incorporated into the plan.

1.4.4 Health and Safety

Health and safety measures will be implemented in accordance with a site-specific Accident Prevention Plan (APP)(Gilbane, 2018a)) that includes a Site Safety and Health Plan (SSHP), and Radiation Protection Plan (RPP)(Gilbane, 2018b)) that were developed and will be maintained as “living” documents under separate cover from this work plan.

An activity hazard analysis (AHA) for tasks to be performed is included in the APP/SSHP. Field changes will be documented and added/amended to the AHA and the APP/SSHP as appropriate. Using information gathered as part of the AHA, engineering controls, work practices, personal protective equipment (PPE), or a combination of these will be implemented to protect workers by eliminating or effectively controlling the identified hazards. Engineering controls and work practices will be used to the greatest extent possible, supplemented by PPE as appropriate, to maintain a safe work site. References used to develop the APP/SSHP include, but are not limited to Title 29, Code of Federal Regulations, Section 1910.120 (Hazardous Waste Operations and Emergency Response [HAZWOPER]), the U. S. Army Corps of Engineers (USACE) *Safety and Health Requirements*, Manual No. 385-1-1 (USACE, 2014), and UFGS Specification 01 35 26, *Governmental Safety Requirements* (UFGS, 2017a).

The RPP addresses radiation protection activities such as personnel dosimetry, radiation monitoring, contamination control, air sampling, and respiratory protection, as well as measures to maintain exposures to radiation and radioactive material as low as reasonably achievable. Personnel surveys, equipment and material surveys, and decontamination are also addressed in the RPP. Corporate-level radiation safety procedures provide controls necessary for radiologically safe operations that will be followed for implementation of field work.

1.4.5 Environmental Protection Plan

Environmental protection measures will be implemented according to the Environmental Protection Plan in Appendix D. The Environmental Protection Plan includes a CERCLA Storm

Water Management Plan (SWMP) and a Dust Control Plan that meet the substantive requirements of the applicable, relevant, and or appropriate regulations (ARARs) for storm water and dust mitigation as well as the unique needs encountered based on the public's concerns regarding work at HPNS.

The CERCLA SWMP describes the best management practices to be implemented, including erosion and sediment control, waste management and disposal spill responses, post-removal/remediation controls, site inspection and monitoring programs, responsible personnel, training requirements, and certifications and compliance requirements. The CERCLA SWMP implements the substantive provisions of the California State Water Resources Control Board National Pollutant Discharge Elimination System (NPDES) General Permit to comply with federal Clean Water Act ARARs and state water quality ARARs for discharge to surface water. A general NPDES stormwater construction permit is not required because the activities are being conducted under Section 121(e) of CERCLA.

The Dust Control Plan integrates into the *Basewide Dust Control Plan, Hunters Point Shipyard, San Francisco, California* (TetraTech EC, Inc. [TtEC], 2010) and outlines how dust control measures are applied at HPNS. The Dust Control Plan addresses the substantive requirements of air quality ARARs for construction and environmental remediation operations and Title 17, California Code of Regulations, Section 93105, *Asbestos Airborne Toxic Control Measures for Construction, Grading, Quarrying, and Surface Mining Operations*. Air monitoring will be performed at upwind and downwind locations during activities with the potential for generating dust. Air monitoring will be performed for radionuclides of concern, asbestos, particulate matter less than 10 microns in diameter (PM10), and total suspended particulates, which also will be analyzed for lead and manganese (see Dust Control Plan, Section 5.0).

1.4.6 Survey Unit Work Packages

Stand-alone work packages will be prepared to guide the remediation and survey activities within each survey unit. Each work package will describe the survey unit, its condition and classification, the M&E to be removed, the nature and extent of the remediation to be performed, and the surveys to be performed. Previously collected radiological data will be used to inform the survey design; however, only definitive data generated by Gilbane will be used to support

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any conclusion for radiological release to unrestricted use. See Section 6.4 for additional detail regarding work package preparation.

1.5 TRAINING

On-site project personnel, including contractors, subcontractors, and visitors, will be required to be familiar with work control documents applicable to their specific responsibilities and duties, and will be given radiation awareness training. Project personnel will be trained to a level required by their job functions and responsibilities. Workers who may be exposed to hazardous conditions will have had a physical examination within the last 12 months and have received the following training, at a minimum:

- 40-hour (and 8-hour annual refresher) HAZWOPER training;
- Radiation awareness training.

Copies of training certificates for on-site project personnel will be maintained on the site.

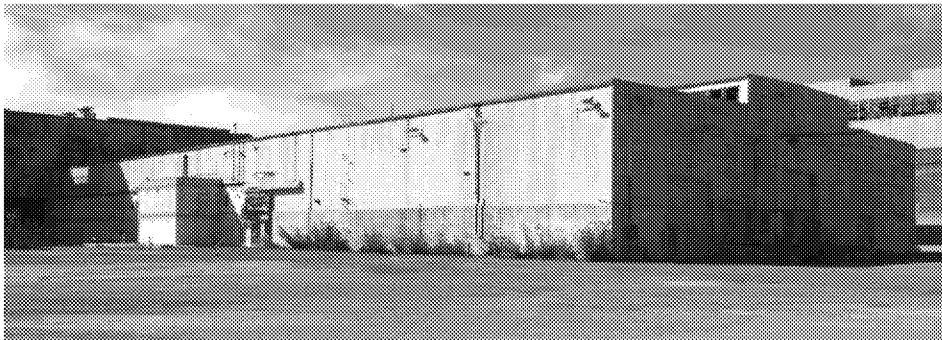
2.0 BUILDING DESCRIPTION AND BACKGROUND

The *Final Hunters Point Shipyard Historical Radiological Assessment, Volume II, History of the Use of General Radioactive Materials, 1939–2003* (HRA; Naval Sea Systems Command [NAVSEA], 2004) provides a comprehensive history of radiological operations conducted by the Navy and its contractors at HPNS. The following subsections present the current understanding of the radiological conditions of Buildings 211 and 253. Possible sources of contamination and the potential exposure pathways are identified to guide data collection and remediation efforts within the survey design. Previous radiological investigations and surveys have been conducted in Buildings 211 and 253.

2.1 BUILDING 211

Building 211, shown in Exhibit 2-1, is located in the eastern portion of Parcel C, immediately adjacent to Building 253, and west of Ship Berths 1 and 2. Constructed in 1942, Building 211 is a ~~three-story~~ concrete-framed, curtain-walled, warehouse-type structure. A large gantry crane located within Building 211 was used for moving materials within the building. A two-story extension was attached to the south side of Building 211. Due to structural instability, the extension was demolished in September 2013 and only the concrete foundation of the extension remains.

Exhibit 2-1. Building 211 (looking northwest)



2.1.1 Previous and Current Use

Building 211 is currently unoccupied. It previously was used as a machinery and electrical test/repair shop, including a welding shop, and a former contractor LLRW storage site.

2.1.2 Planned Future Use

Following its radiological release to unrestricted use and completion of CERCLA clean-up activities, Building 211 will be transferred to the City and County of San Francisco along with the land for Parcel C. The future planned use for this area of Parcel C will be in accordance with the *Hunters Point Shipyard Redevelopment Plan* (San Francisco Redevelopment Agency [SFRA], 2010), which identifies the planned re-use as a “Research and Development” area.

2.1.3 Conceptual Site Model

The HRA (NAVSEA, 2004) identified a moderate potential for radioactive contamination of the Building 211 structure due to welding shop activities and storage of LLRW as possible sources. Based on these possible sources, the floor has the highest potential for contamination. There is also a small potential for some radioactive materials to have come into contact with the lower walls, resulting in contamination. Therefore, the floors and lower walls (to a height of approximately 6 feet [2 m]) are considered potentially impacted by radiological activities.

The most likely source of contamination would be thorium (Th)-232 from refractory compounds and welding electrodes. Any contamination of the floors and lower walls, including installed M&E, would be localized based on where those activities occurred, resulting in relatively small areas with significantly higher radioactivity than the surrounding areas (i.e., small areas of elevated radioactivity). LLRW is routinely stored in containers to prevent the spread of contamination, so the potential for contamination from historical LLRW storage would be low.

The HRA may have inadvertently excluded Pu-239 and Sr-90 as ROCs for Building 211; therefore, these ROCs have been added for Building 211.

2.1.4 Previous Radiological Surveys

The conceptual site model above is consistent with the findings of previous radiological surveys conducted in Building 211. A radiological investigation of Building 211 conducted in 2002 (NAVSEA, 2004) identified a small area of Th-232 contamination on the floor. The radiological characterization of Building 211, conducted in 2013 and documented in the *Characterization*

Survey Results – Building 211, Hunters Point Naval Shipyard, San Francisco, California (TtEC, 2017a), identified fixed contamination (i.e., radioactivity above the remediation goal) at several locations on the floor, lower walls, and on remaining M&E (e.g., electrical panel/system rack, steam cleaner, wooden staircase ~~leading to storage area above small office area~~, and transformer and electrical panel). Limited removal of contaminated M&E, including ventilation system components, was performed as part of the TtEC radiological characterization. Exhibit 2-2 summarizes the suspected contamination remaining in Building 211 documented by TtEC. Surface radioactivity is in units of disintegrations per minute per 100 square centimeters (dpm/100 cm²). Volumetric radioactivity is in units of picocuries per gram (pCi/g).

Exhibit 2-2. Summary of Suspected Contamination Remaining in Building 211

Description of Contamination	Surface Contamination (dpm/100 cm ²)				Volumetric Contamination (pCi/g)		
	Fixed		Removable				
	Alpha	Beta	Alpha	Beta	Cs-137	Ra-226	Th-232
Floor	253	12,800	---	---	---	---	---
Wall	230	2,860	---	---	---	---	---
Machine base pit	---	---	---	---	---	2.03	---
M&E (elec panels/racks)	265	17,400	---	---	---	---	---

Source: *Characterization Survey Results – Building 211* (TtEC, 2017a).

Cs-137 = cesium-137; Ra-226 = radium-226; Th-232 = thorium-232

2.2 BUILDING 253

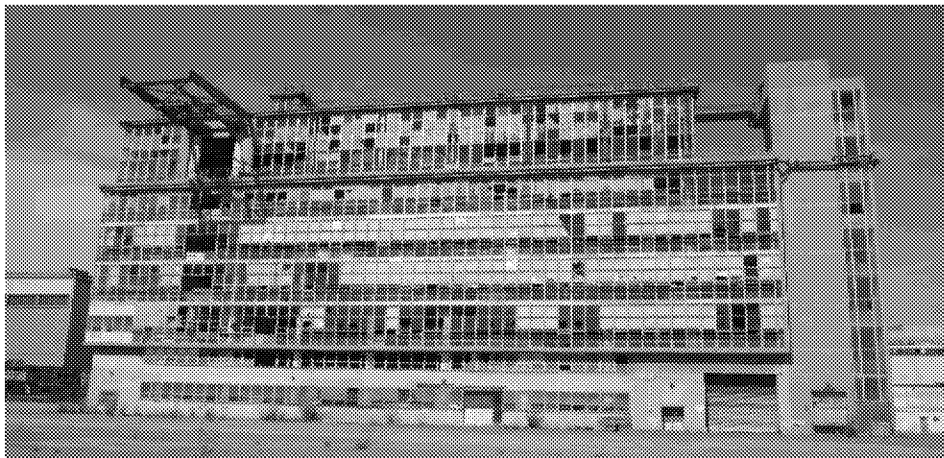
The east end of Building 253 is connected to the west end of Building 211 and the entire building is located in the eastern portion of Parcel C that is west of Ship Berths 1 and 2. Constructed between 1944 and 1947, Building 253 is a six-story, concrete-framed structure with a glass curtain wall. The structure has a large gantry for moving equipment to the upper stories by crane and a periscope tower extending vertically from the 6th floor roof. These building features are illustrated in Exhibit 2-3.

2.2.1 Previous and Current Use

Building 253 is unoccupied. It previously was used to conduct radiography and instrument calibration. The 5th floor of Building 253 housed the ordnance shop, optical shop, gauge repair facility, and calibration range. ~~An accelerator was housed in the enclosed portion of the 6th floor.~~ In addition, the building was used to store equipment removed from OPERATION CROSSROADS ships. OPERATION CROSSROADS was a series of nuclear weapon tests

conducted by the U.S. in the South Pacific in 1946. Ships involved in OPERATION CROSSROADS were brought to HPNS for radiological decontamination services.

Exhibit 2-3. Building 253 (looking north)



2.2.2 Planned Future Use

Following radiological release to unrestricted use and completion of CERCLA clean-up activities, Building 253 will be transferred to the City and County of San Francisco along with the land for Parcel C. The future planned use for this area of Parcel C will be in accordance with the *Hunters Point Shipyard Redevelopment Plan* (SFRA, 2010), which identifies the planned re-use as a “Research and Development” area.

2.2.3 Conceptual Site Model

The HRA (NAVSEA, 2004) identified a high potential for radioactive contamination of the Building 253 structure due to activities associated with the optical shop, gauge repair facility, and calibration facilities. Optical shops are known commonly to have worked with radium-bearing devices, as well as with thoriated glass. Radiography equipment and sources were used, stored, and maintained in Building 253. The building has also been identified as a possible location of a radium paint shop. Another possible source of contamination is the storage of equipment removed from OPERATION CROSSROADS ships.

Based on the possible sources, the floor ~~and drains have~~ has the highest potential for contamination. There is also a potential for radioactive materials to have come into contact with the lower walls, drain lines, and the ventilation system (including ceiling and upper walls), resulting in contamination.

2.2.4 Previous Radiological Surveys

The conceptual site model above is consistent with the findings of previous radiological surveys conducted in Building 253. A radiological investigation conducted in 2002 (NAVSEA, 2004) revealed low-level contamination throughout the building, ventilation shafts, piping, and manholes, and on a ledge outside the building. Limited remediation of the 5th and 6th floors, the roof, and parts of the ventilation system was performed at that time.

A radiological characterization of Building 253, conducted in 2013 and documented in *Characterization Survey Results – Building 253, Hunters Point Naval Shipyard, San Francisco, California* (TtEC, 2017b), identified contamination throughout the building on floors and structural columns, in ventilation systems and drain lines, and on remaining electrical panels, racks, and electrical boxes. Limited removal of contaminated M&E, including ventilation system components, was performed as part of the radiological characterization. Exhibit 2-4 summarizes the suspected contamination remaining in Building 253 documented by TtEC.

Fixed and removable contamination requiring survey and potential remediation exists in several locations on all six floors of the building. Contaminated M&E, including ventilation system components and approximately 1,800 linear m of contaminated drain lines distributed on several floors of the building, remain in place. Sediment samples collected from above-ground metal drain lines and vent stacks reported Cs-137, Ra-226, and Th-232 contamination. Drain line contamination is evidence of radioactive material in liquid form that was either spilled or disposed purposely down the drains. Ventilation system contamination is evidence of airborne radioactivity that also could have impacted upper walls and ceilings. Contaminated dirt and debris of unknown origin are contained in eight wooden crates on the 6th floor that remain in the building. The asphaltic brick and grout surface on the exterior promenade area of the 6th floor may also be contaminated.

Exhibit 2-4. Summary of Suspected Contamination Remaining in Building 253

Floor	Description of Contamination	Surface Contamination (dpm/100 cm ²)				Volumetric Contamination (pCi/g)		
		Fixed		Removable				
		Alpha	Beta	Alpha	Beta	Cs-137	Ra-226	Th-232
1	Floor	---	1,420	---	---	---	---	---
	Structural columns	---	6,370	---	---	---	---	---
	Metal drain lines	168	---	---	---	---	1.75	---
	Paint Booth Exhaust Vent	---	---	---	---	3.81	5.77	---
	M&E (elec panels/racks)	9,230	41,100	906	2,060	---	---	---
2	Floor	117	---	---	---	---	---	---
	Metal drain lines	90	---	---	---	0.380	3.23	9.22
	Concrete vent stack/deck	---	1,690	---	---	0.855	2.46	---
	M&E (electrical panels)	265	14,900	---	---	---	---	---
3	Floor (Cal Rm, Rm 4)	3,890	8,650	51	---	---	---	---
	Structural columns	8,090	20,500	40	---	---	---	---
	Oven exhaust pipe	39	---	---	---	---	---	---
	Vent stacks/decks	---	1,990	---	---	0.437	---	---
4	Floor (Spray Rm)	4,090	40,700	63	---	---	---	---
	Metal drain lines	---	---	---	---	0.128	9.58	---
	Paint Shop exhaust stack	---	1,930	---	---	0.396	---	---
5	Floor (Cleaning Rm)	2,650	30,800	---	---	---	---	---
	Metal drain lines	---	---	---	---	1.92	1.58	---
	Structural columns	558	7,430	51	---	---	---	---
6	Floors	808	4,160	---	---	---	---	---
	Dirt pile (in wooden crates)	---	---	---	---	0.628	---	---
	Ext promenade (brick/grout)	---	1,400	---	---	---	---	---

Source: *Characterization Survey Results – Building 253* (TtEC, 2017b).
Cs-137 = cesium-137

2.3 REMAINING SANITARY SEWER AND STORM DRAIN LINES

The HRA (NAVSEA, 2004) identified a low potential for contamination of the drainage system in Building 211 and a high potential for contamination of the drainage system in Building 253. Following this evaluation, the HRA (NAVSEA, 2004) identified the potential for subsurface soil contamination related to Buildings 211 and 253 as low and moderate, respectively. The remaining SSSD lines are shown on Figure 2.

DRAFT Work Plan
Parcel C Buildings 211 and 253 Radiological Remediation
Hunters Point Naval Shipyard, San Francisco, California

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3.0 RELEASE CRITERIA

Achieving the radiological release of Buildings 211 and 253 to unrestricted use is a process that employs compliance with release criteria to ensure that residual radioactivity will not result in members of the general public being exposed to unacceptable levels of radiation. Residual radioactivity will be assessed against three elements that form the release criteria. They are:

- Remediation Goal: The ~~average~~ total surface radioactivity and/or soil (or volumetric) radioactivity are less than the radionuclide-specific remediation goals found in Table 5 of the Parcel C ROD (Navy, 2010; see also Exhibit 3-2);
- Dose: The total effective dose equivalent (TEDE) to an average individual reasonably expected to receive the greatest exposure to residual radioactivity is less than 12 millirem per year (mrem/yr) based on U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-40, *Radiation Risk Assessment at CERCLA Sites: Q&A* (EPA, 2014); and
- Risk: The excess cancer risk to an average individual reasonably expected to receive the greatest exposure to residual radioactivity is in the range of 10^{-4} to 10^{-6} based on EPA OSWER Directive 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* (EPA, 1997).

Survey data will be compared to the remediation goals and the comparison used to make decisions regarding data collection activities in the field (i.e., investigation, remediation, reclassification, and resurvey as described in Section 5.7). Once compliance is demonstrated with the first element, the survey data will be used to calculate dose and risk to verify compliance with the last two elements.

3.1 RADIONUCLIDES OF CONCERN

Residual radioactivity is measured in the form of specific radionuclides of concern. The radionuclides of concern that will be assessed are identified in the HRA (NAVSEA, 2004) for Building 253 as strontium (Sr)-90, Cs-137, Ra-226, Th-232, and plutonium (Pu)-239. For Building 211, the HRA (NAVSEA, 2004) identifies Cs-137, Ra-226, and Th-232. Sr-90 and Pu-239 were not included in the HRA (NAVSEA, 2004); however, they have been added to the list of radionuclides of concern for Building 211 to be consistent with Building 253. The method of detection for each radionuclide of concern is given in Exhibit 3-1. Their use, natural presence, half-life, and mode of decay are discussed in Appendix E.

Exhibit 3-1. Radionuclides of Concern

Radionuclide of Concern	Method of Detection	
	Particle Emission	Energy (MeV) ^a
Sr-90 ^b	beta	0.20, 0.94
Cs-137	beta	0.19, 0.42
Ra-226 ^c	alpha	4.8, 5.5, 6.0, 7.7
Th-232 ^d	alpha	4.0, 5.4, 5.7, 6.3, 6.8, 2.2
Pu-239	alpha	5.1

Notes:

^a average energy listed for beta particles

^b in equilibrium with progeny yttrium (Y)-90; effectively results in two beta emissions per atomic transformation of Sr-90

^c in equilibrium with multiple progeny – see Appendix E; effectively results in four alpha emissions per atomic transformation of Ra-226

^d in equilibrium with multiple progeny – see Appendix E; effectively results in at least six alpha emissions per atomic transformation of Th-232

MeV = mega-electron volts

3.2 REMEDIATION GOALS FOR RADIONUCLIDES

Survey data will be compared to the remediation goals established in Table 5 of the Parcel C ROD (Navy, 2010). The remediation goals are also listed in Exhibit 3-2. Those applicable to total surface radioactivity are expressed in dpm/100 cm². Those applicable to soil (or volumetric) radioactivity are expressed in units of pCi/g. The rules for analyzing samples for soil (or volumetric) activity are given in Section 8.9.

Exhibit 3-2. Remediation Goals for Radionuclides

Radionuclide of Concern	Total Surface Radioactivity (dpm/100 cm ²) ^{a,b}	Soil (or Volumetric) Radioactivity (pCi/g) ^a
Sr-90	1,000	0.331
Cs-137	5,000	0.113
Ra-226	100	1.0 ^c
Th-232	36.5 ^d	1.69
Pu-239	100	2.59

Notes:

^a values taken from Table 5 of the Parcel C ROD (Navy, 2010)

^b removable surface radioactivity is limited to 20 percent of total surface radioactivity

^c goal is 1 pCi/g above background per agreement with EPA

^d equivalent to a field measurement of 212 dpm/100 cm², which represents Th-232 at its remediation goal of 36.5 dpm/100 cm² given in Table 5 of Parcel C ROD (Navy, 2010) assuming Th-232 in secular equilibrium with its progeny

3.2.1 Thorium-232 in Secular Equilibrium

Table 5 of the Parcel C ROD (Navy, 2010) gives the remediation goal for Th-232 for total surface radioactivity as 36.5 dpm/100 cm². Radioactivity at this level is difficult to detect reliably since it is at the lower limit of detection for field instrumentation (see discussion in Section 5.6.3). Due to its extremely low value, for quantification purposes Th-232 is assumed to be in secular equilibrium with its progeny. This is a reasonable assumption given that a sufficient number of half-lives have elapsed for progeny in-growth to have reached secular equilibrium. According to the HRA (NAVSEA, 2004), HPNS ceased to function as an operational Navy shipyard in 1974, though limited operations occurred between 1986 and 1989. The half-lives of Th-232 progeny are 6 years or less, meaning that seven or more half-lives have elapsed during the approximate 44-year period since shipyard operations were discontinued. In secular equilibrium, the effective number of parent and progeny alpha particles emitted for each Th-232 disintegration is six (see explanation provided in Appendix E). Therefore, the Table 5 remediation goal for Th-232 (36.5 dpm/100 cm²), provided it is in secular equilibrium with its progeny, is equivalent to a field measurement can be applied as a multiple of six times (6 x 36.5 dpm/100 cm², or 219 dpm/100 cm²).

3.2.2 Gross vs. Radionuclide-Specific Measurements

To eliminate the need for (and in the absence of) radionuclide-specific identification, measurements of alpha- and beta-emitting surface radioactivity will be compared to 100 dpm/100 cm² and 1,000 dpm/100 cm², respectively. These values are the most limiting for each type of particle emission (i.e., Ra-226 for alpha and Sr-90 for beta as shown in Exhibit 3-2). Alpha- and beta-emitting removable surface radioactivity is limited to 20 percent of total surface radioactivity, or 20 dpm/100 cm² and 200 dpm/100 cm², respectively. This is consistent with the remediation goals in the Parcel C ROD (Navy, 2010) prescribed to release equipment and waste from radiological controls.

3.3 DOSE AND RISK MODELING

Dose and risk modeling will be performed using the survey data to determine whether residual radioactivity, distinguishable from background, will result in a TEDE less than or equal to 12 mrem/yr and an excess cancer risk between 10⁻⁴ to 10⁻⁶ to an average member of the critical group. The critical group is composed of the individuals reasonably expected to receive the

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greatest exposure to residual radioactivity within the assumptions of the particular exposure scenario.

3.3.1 EPA Guidance

EPA OSWER Directive 9200.4-40 (EPA, 2014) establishes the Superfund recommendation of 12 mrem/yr as the dose-based applicable or relevant and appropriate requirement (ARAR) considered to be protective. The EPA's 12 mrem/yr recommendation equates to approximately 3×10^{-4} increased lifetime risk and is consistent with levels generally considered protective in other governmental actions, particularly regulations and guidance developed by EPA in other radiation control programs.

EPA OSWER Directive 9200.4-18 (EPA, 1997), provides clarification on establishing protective clean-up levels for radioactive contamination at CERCLA sites. Clean-ups of radionuclides are governed by the risk range for carcinogens established in the National Oil and Hazardous Substances Pollution Contingency Plan when ARARs are not available or are not sufficiently protective. Clean-ups generally should achieve a level of risk within the 10^{-4} to 10^{-6} carcinogenic risk range based on the reasonable maximum exposure for an individual.

3.3.2 Exposure Scenarios

Dose and risk levels for the critical group will be derived using computer modeling software codes developed by Argonne National Laboratory (ANL) for the U.S. Department of Energy (DOE) and the NRC to evaluate radioactively contaminated sites and buildings. For Buildings 211 and 253, RESRAD-BUILD for Windows, Version 3.5 (ANL, 2009) will be used to calculate a hypothetical dose and risk to members of the general public based on a building occupancy scenario. For the trenches excavated to remove the SSSD lines, RESRAD-ONSITE for Windows, Version 7.2 (ANL, 2016) will be used to calculate a hypothetical dose and risk to members of the general public based on a suburban resident scenario.

The software codes are designed to analyze radiation doses from residual radioactivity using various pathways and scenarios (e.g., direct radiation, inhalation, ingestion) through which exposures could occur. The exposure scenarios and their modeling are specifically designed to be "reasonably conservative" by generally overestimating rather than underestimating potential

dose and risk. Detailed descriptions of the exposure scenarios, including the methodology and assumptions that will be used to calculate dose and risk, are found in Section 9.5.

3.4 CONDITIONS SATISFYING THE RELEASE CRITERIA

Buildings 211 and 253 will be considered suitable for radiological release to unrestricted use when the remediation goal, dose, and risk elements of the release criteria are met. The following conditions satisfy those elements:

- Remediation Goal: The average residual radioactivity above background is less than the remediation goal. ~~Where one or more individual measurements exceed the remediation goal, the average residual radioactivity passes the Sign or Wilcoxon Rank Sum (WRS) statistical test. The application of the statistical test is described in Section 9.4.~~
- Dose: The TEDE to an average member of the critical group is less than 12 mrem/yr calculated based on (1) the building occupancy scenario for Buildings 211 and 253 or (2) the suburban resident scenario for trenches excavated to remove the SSSD lines.
- Risk: The excess cancer risk to an average member of the critical group is in the range of 10^{-4} to 10^{-6} calculated based on (1) the building occupancy scenario for Buildings 211 and 253 or (2) the suburban resident scenario for trenches excavated to remove the SSSD lines.

4.0 DATA QUALITY OBJECTIVES

The EPA's *Guidance on Systematic Planning using the Data Quality Objectives Process* (EPA, 2006) was used to develop data quality objective (DQOs) to achieve radiological release of Buildings 211 and 253 to unrestricted use in a manner consistent with the remedial action objective in the Parcel C ROD (Navy, 2010). DQOs are qualitative and quantitative statements developed to define the purpose of the data collection effort, clarify what the data should represent to satisfy this purpose, and specify the performance requirements for the quality of information to be obtained from the data.

4.1 STEP 1 – STATEMENT OF THE PROBLEM

The Navy would like to obtain the radiological release of Buildings 211 and 253 to unrestricted use; i.e., compliance with the remediation goals established in the Parcel C ROD (Navy, 2010). The HRA (NAVSEA, 2004) identified Buildings 211 and 253 as radiologically impacted by activities that occurred within the buildings involving radionuclides. Radioactive contamination is known to exist within the buildings. Therefore, remediation is necessary, followed by radiological survey to verify the remedial effort was effective, and to provide survey data of sufficient quality to support radiological release of the buildings to unrestricted use.

4.2 STEP 2 – DECISION STATEMENT

The principal study question to be answered by the survey data is: “Is the ~~average~~-residual radioactivity above background less than the remediation goals?” Total and removable surface radioactivity measurements and volumetric sample analytical results will be used to answer the question quantitatively.

The following alternative actions result from resolution of the principal study question:

- If the ~~average~~-residual radioactivity above background does not exceed the remediation goals, then perform dose and risk modeling to determine suitability for radiological release to unrestricted use.
- If the ~~average~~-residual radioactivity above background exceeds the remediation goals, then perform remediation and repeat the radiological survey.

Based on the principal study question and the alternative actions listed above, the decision statement is: "Determine whether or not the average residual radioactivity exceeds the remediation goals."

The decision is formulated into statistical hypotheses defined in Scenario A of NUREG-1505, 4. Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys (NRC 1998) and MARSSIM (DoD et al. 2000). The state that is presumed to exist in reality is expressed as the null hypothesis (denoted by H_0). For this scenario, the null hypothesis is:

- ◆ H_0 : The average residual radioactivity exceeds the remediation goals.

For the given null hypothesis, the alternative hypothesis (denoted as H_a), which is an expression of what is believed to be the state of reality if the null hypothesis is not true, is:

- ◆ H_a : The average residual radioactivity does not exceed the remediation goals.

As the null and alternative hypotheses are applied here, Buildings 211 and 253 will not be considered suitable for radiological release to unrestricted use unless the survey data show that the average residual radioactivity is less than the remediation goals.

4.3 STEP 3 – INPUTS TO THE DECISION

The radionuclides of concern are listed in Exhibit 3-1. The impacted media are building materials (including ventilation systems and aboveground piping), exposed trench surfaces, and soil used to backfill the trenches. For building surfaces, alpha/beta contiguous static measurements and samples of removable surface radioactivity (smears) analyzed for gross alpha/beta radioactivity will be used as quantitative inputs. For excavated trenches, volumetric samples analyzed by gamma and/or alpha spectroscopy will be used as quantitative inputs. Gamma scans will be used as qualitative inputs.

4.4 STEP 4 – BOUNDARIES OF THE STUDY

The target population is radioactivity concentrations of the radionuclides of concern on and/or in the impacted media. The spatial boundaries include the buildings and their footprints, including a 15-foot (5-m) wide perimeter around the buildings and exposed soil to a depth of six inches (15 centimeters [cm]). The perimeter around the buildings is the assumed extent of remaining

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SSSD lines that emanate from the buildings that were not removed during previous time critical removal activities; however, excavation, survey, and sampling activities will follow SSSD lines to termination.

Decisions will be made on three fundamental scales:

- Localized areas: The decision to collect additional data will be made for discrete areas with measurement results that exceed the investigation levels (see Section 5.7.1).
- Survey unit: Buildings 211 and 253 were divided into survey units based on similar physical characteristics and potential for residual radioactivity. A decision will be made for each survey unit as to its suitability for radiological release to unrestricted use or, alternatively, its need for remediation and/or additional data collection.
- Entire building: Survey data will be evaluated on a building-wide basis and used to support the decision regarding suitability for radiological release to unrestricted use.

4.5 STEP 5 – DECISION RULES

The decision rules identified in Exhibit 4-1 will be used to collect data. The decision rules define the logic for how the data are used to determine follow-on actions or draw conclusions.

Exhibit 4-1. Decision Rules

Parameter of Interest	IF	THEN	ELSE
Total and Removable Radioactivity	Contiguous static measurements and/or smear samples exceed investigation level	Investigate to determine the area of elevated radioactivity, remediate, and/or resurvey	Perform statistical test dose and risk modeling
Volumetric Radioactivity	Areas identified with measured radioactivity above investigation level	Investigate to determine the area of elevated radioactivity, remediate, and/or resurvey	Collect soil samples
	Soil samples exceed investigation level	Investigate to determine the area of elevated radioactivity, remediate, and/or resurvey	Perform statistical test dose and risk modeling
Average Residual Radioactivity	Statistical test results fail to reject null hypothesis	Remediate and/or resurvey	Perform dose and risk modeling

The objective is to collect data of a sufficient type, quantity, and quality such that the statistical test can be applied (see Section 9.4) and conclusions can be drawn with confidence regarding the radiological condition of the survey unit, i.e., whether the average-residual radioactivity is below the remediation goals.

4.6 STEP 6 - LIMITS ON DECISION ERRORS

To ensure data quality, data will be reviewed, verified, and validated in accordance with the SAP (Worksheets #34, 35, and 36). To ensure the usability of laboratory data, appropriate laboratory methods (see Section 8.9) will be selected to provide the necessary laboratory detection limits.

4.7 STEP 7 - OPTIMIZING THE SURVEY DESIGN

Steps 1 through 6 of the DQO process above and the SAP describe a resource-effective design for collecting data sufficient to meet the design objectives. The survey and sampling (and analysis) design provides near real-time data evaluation during implementation of field activities. The results are used to refine the scope of field activities, as needed, to optimize implementation of the survey and sampling design and ensure the DQOs are met.

5.0 SURVEY DESIGN AND DATA COLLECTION

The outputs from the DQO process and guidance from the MARSSIM (DoD et al., 2000) were used to develop the survey design. The desired outputs in terms of data quality were defined using the DQO process. MARSSIM guidance in the nature of site survey and investigation tools were selected for use to achieve the desired outputs identified by the DQOs. The survey design integrates both probability-based (random and random-start/systematic) and judgmental (biased) data collection methods to achieve the DQOs. The survey design was constructed to meet the data quality requirements of a final status survey (FSS) such that if the ~~average~~-residual radioactivity does not exceed the remediation goals, the collected data set will be used as the FSS to support radiological release to unrestricted use. MARSSIM (DoD et al., 2000) recommends this approach when ~~the survey is considered confirmatory and all~~ removal and remediation activities have been completed.

Buildings 211 and 253 were divided into Class 1, Class 2, and Class 3 areas based on potential for residual radioactivity above the remediation goals as recommended in MARSSIM. The classification determines the survey unit size, which in turn, specifies the survey intensity; i.e., the survey coverage and measurement frequency. Contiguous static measurements and smear samples will be collected from building surfaces. Gamma scans and soil samples will be collected from the excavated trenches. Survey data will be collected using calibrated instruments following established protocols. Data investigation, additional remediation, reclassification, and/or resurvey will be performed as required to ensure that survey data are sufficient to conclude the ~~average~~-residual radioactivity meets the remediation goals. Reference areas will be used to establish background levels of radioactivity in order to assess residual radioactivity attributable to legacy Navy operations at HPNS.

5.1 CLASSIFICATION

Buildings 211 and 253 were divided into Class 1, Class 2, and Class 3 areas per MARSSIM. Classification was based on radiological characterization data and the history of radioactive materials involvement or the known potential for radioactive contamination of an area. The classification process incorporated the working hypothesis that all radiologically impacted areas have a potential for residual radioactivity attributable to legacy Navy operations at HPNS above

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the remediation goals. This initial assumption means that areas were initially considered Class 1 areas unless some basis for classification as Class 2 or Class 3 was identified.

5.1.1 Class 1 Areas

Class 1 areas are areas where, prior to remediation, there are expected to be locations with residual radioactivity above the remediation goals. Materials and surfaces that have been preliminarily remediated under previous task orders or are suspected to have residual radioactivity attributable to legacy Navy operations at HPNS above the remediation goal were classified as Class 1 areas.

5.1.2 Class 2 Areas

Class 2 areas are areas where, prior to remediation, there are expected to be locations with residual radioactivity detectable above background levels, but not above the remediation goals. Floors and lower wall surfaces not classified as Class 1 areas were classified as Class 2 areas.

5.1.3 Class 3 Areas

Class 3 areas are areas where there are not expected to be locations with residual radioactivity detectable above background levels. Materials and upper wall and ceiling surfaces not classified as Class 1 or Class 2 areas were classified as Class 3 areas.

5.2 SURVEY UNITS

As listed in Table 1 and illustrated in Figures 4 through 10, Buildings 211 and 253 were divided into survey units. A survey unit is a physical area of specified size and shape with consistent characteristics and potential for residual radioactivity for which data evaluation and statistical analysis are performed. A separate decision is made for each survey unit as to its suitability for release.

Considerations for establishing survey units are physical characteristics, concentration levels, and previous remediation efforts, as well as spatial and logistical considerations. Survey unit size suggested in MARSSIM (DoD et al., 2000), in units of square meters (m²), is shown in Exhibit 5-1.

Exhibit 5-1. MARSSIM Suggested Survey Unit Size

Class	Floor Area (m ²)	Land Area (m ²)
1	100	2,000
2	1,000	10,000
3	No limit	No limit

Survey unit sizes are given in Table 1. Survey units were sized to ensure that survey data points are relatively uniformly distributed among areas of similar potential for residual radioactivity. Survey unit configurations are shown in Figures 4 through 10. Survey units conform to building characteristics to the extent practical. They have relatively compact shapes, unless an unusual shape is appropriate for the operational history or building configuration. Where possible, existing building characteristics such as existing walls, structural support beams, concrete pour seams, or piping runs were used to define the boundaries of the survey units. Paint, tape, or other suitable method will be used to mark survey unit boundaries in the field.

General rules used to establish survey units in accordance with MARSSIM guidance included:

- Materials and surfaces previously remediated or suspected to have radioactivity above the remediation goals were classified as Class 1 survey units and limited in floor area to 100 m².
- Floors and lower wall surfaces not classified as Class 1 areas were classified as Class 2 survey units and limited in floor area to 1,000 m².
- Materials and upper wall and ceiling surfaces not classified as Class 1 or Class 2 areas were classified as Class 3 areas with no limit on floor area.
- Survey units were limited to a single predominant material type with as few other material types possible. For example, an area with two predominant material types was broken into two survey units.

5.3 SURVEY MEASUREMENTS

Four types of survey measurements will be collected. Contiguous static measurements and smear samples will be collected from building surfaces. They are described in Sections 7.4 and 7.5. Gamma scans and volumetric samples will be collected from excavated trenches. They are described in Sections 8.7 and 8.8.

5.4 SURVEY COVERAGE

Survey coverage is the percentage of accessible surface area from which measurements will be collected. The survey coverage by survey classification suggested in MARSSIM (DoD et al., 2000) is shown in Exhibit 5-2. As a matter of practice, where survey coverage greater than 50 percent is judged appropriate, the survey unit will be reclassified as a Class 1 survey unit.

Exhibit 5-2. MARSSIM Suggested Survey Coverage

Class	Survey (formerly Scan) Coverage
1	100%
2	10 to 50% ^a
3	Judgmental

Note:

^a survey unit is reclassified as a Class 1 survey unit where survey coverage greater than 50% is judged appropriate

For other than Class 1 areas, survey coverage areas will be selected from those areas of highest potential for elevated radioactivity (e.g., collection points such as horizontal surfaces, ventilation openings, water collection points, etc.). This provides a qualitative level of confidence that areas with potential elevated radioactivity are surveyed. If the entire survey unit has an equal probability for areas of elevated radioactivity, survey coverage areas will be systematic based on survey unit transects for simple two-dimensional surfaces or randomly selected grid blocks for multi-dimensional or obstructed surfaces, including equipment. In addition, survey coverage for Class 2 and Class 3 survey units will be determined using a random-start systematic method.

5.5 REFERENCE COORDINATE SYSTEM

Horizontal coordinates will be based on the North American Datum (NAD) 27 Zone-III (Hunters Point West 1 PID HT0613). Vertical elevations, if used, will be based on the National Geodetic Vertical Datum (NGVD) 29. Scale drawings, maps, or photographs of the survey area will be prepared and oriented according to the reference coordinate system. The reference coordinate system is intended primarily for reference purposes, and does not necessarily dictate the actual spacing or location of measurements, which will be denoted using markings in the field.

5.6 FIELD SURVEY INSTRUMENTS

Survey data will be collected using the types of field survey instruments (or equivalent) listed in Exhibit 5-3. Commercially available radiation detection and measurement instruments were

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selected based on reliable operation, detection sensitivity, operating characteristics, and expected performance in the field. Instrument calibration, set-up, and ~~response performance~~ checks will be documented and the documentation retained in project records and included in survey reports for QA/QC purposes.

Exhibit 5-3. Survey Instruments

Measurement Type	Detector Type	Effective Detector Area and Window Density	Instrument Model	Detector Model
Alpha/beta contiguous statics	Gas-flow proportional	821 cm ² 3.4 mg/cm ² aluminized Mylar	Ludlum 4612	Ludlum 43-37-1
Alpha/beta smear samples	Gas-flow proportional	5.1 cm diameter 0.08 mg/cm ²	Protean WPC 9550	N/A
	Dual phosphor scintillation	5.1 cm diameter 0.4 mg/cm ²	Ludlum 2929	Ludlum 43-10-1
Gamma scans	NaI scintillation	10 x 10 x 40 cm N/A	RSI RS-700	RSI RSX-1
		5.1 cm diameter/length N/A	Ludlum 2221	Ludlum 44-10

Notes:

cm² = square centimeter(s)

mg/cm² = milligram(s) per square centimeter

N/A = not applicable

NaI = sodium iodide

5.6.1 Instrument Calibration and Maintenance

Survey instruments will be calibrated prior to use in accordance with the RPP. Radioactive sources used for calibration will be traceable to the National Institute of Standards and Technology. Instruments will be inspected prior to use to ensure proper working condition, and properly protected against inclement weather conditions during the operation.

5.6.2 Instrument ~~Response Performance~~

Instrument ~~response performance~~ checks will be conducted to assure constancy in instrument response, to verify that the detector is operating properly, and to demonstrate that measurement results are not the result of detector contamination. Instrument ~~response performance~~ will be checked before instrument use each day data are collected, using a check source that emits the same type of radiation (i.e., alpha, beta, and/or gamma) as the radiation being measured and that gives a similar instrument response. The ~~response performance~~ checks will be performed at a set location using a specified source-detector alignment that can be repeated easily.

Prior to initial instrument use, 20 measurements will be taken using a source representative of the radiation types and energies of interest to calculate instrument efficiency and determine an expected range of instrument response for use in the daily performance check (e.g., mean \pm 2 sigma). The same number of measurements also will be taken with the source removed to determine the instrument's expected response to ambient background. Background will be monitored qualitatively to assess daily variations that may impact the instrument's minimum detectable concentration (MDC; discussed further in Section 5.6.3).

5.6.3 Alpha/Beta Detection Sensitivity

To ensure that prior to each use that each instrument can detect radiation at or below the remediation goals, instrument-specific alpha/beta sensitivity values based on actual field conditions will be used to establish MDCs before the instrument is used. The MDC is the concentration that a specific instrument and technique can be expected to detect 95 percent of the time under actual conditions of use. Typical alpha/beta detection sensitivities of field survey instruments are shown in Exhibit 5-4. The values are based on assumed count times, background counts, and total efficiencies. The MDC is calculated using the method found in Appendix F.

Exhibit 5-4. Typical Alpha/Beta Detection Sensitivities

Detector Model	Radiation of Interest	Count Time (minutes)	Background (cpm)	Total Efficiency ^a (cpm/dpm)	MDC ^b (dpm/100 cm ²)
Ludlum 43-37-1	Alpha	1	7	0.05	29
	Beta	1	1,400	0.13	121
WPC 9550	Alpha	12	40.1	0.150	9214
	Beta	42	4600.9	0.3145	64512
Ludlum 43-10-1	Alpha	2	40.4	0.1820	117
	Beta	2	4075	0.22	14100

Notes:

^a Total efficiency equals instrument efficiency multiplied by surface efficiency (alpha = 0.25, beta = 0.5).

^b MDC is calculated using the method found in Appendix F.

cm² = square centimeters

cpm = counts per minute

dpm = disintegrations per minute

Total efficiency values for the detection of alpha/beta-emitting surface radioactivity will be developed using International Organization for Standardization (ISO) 7503-1, *Evaluation of surface contamination – Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV)*

and alpha-emitters (ISO, 1988). ISO 7503-1 defines total efficiency (ϵ_T) as the product of two terms: the instrument efficiency (ϵ_i) and the surface efficiency (ϵ_s).

Equation 5-1

$$\epsilon_T = \epsilon_i \times \epsilon_s$$

The instrument efficiency is determined based on an average rate of particles detected by the instrument relative to the surface (2π) particle emission rate of the calibration source. The surface particle emission rate is a value measured and certified by the source manufacturer.

The surface efficiency (ϵ_s) is determined based on the rate of particles emerging from the surface of interest in the field relative to the rate of particles being generated from the total (4π) activity present on the surface. Optimally, the surface efficiency is an experimentally determined value specific to the field surface that accounts for its backscatter characteristics as well as geometry influences (e.g., a scabbled concrete surface). In the absence of an experimentally determined value, the following values recommended in ISO 7503-1 are used:

- 0.25 for alpha emitters and beta emitters with a maximum beta energy between 0.15 MeV and 0.4 MeV, and
- 0.5 for beta emitters with maximum beta energy greater than 0.4 MeV.

5.7 DATA INVESTIGATION

Locations with radioactivity that exceeds the investigation level for the respective type of measurement method will be marked and investigated further. The first step in the investigation will be to verify that the elevated measurement actually exceeds the investigation level. This is done by re-collecting measurements at and around the location of interest. The area around the elevated measurement also will be investigated to determine the extent of the elevated radioactivity and to provide reasonable assurance that adjacent undiscovered areas of elevated radioactivity are not present. Survey coverage of the area being investigated will be increased to 100 percent (Class 1). Locations with radioactivity that do not exceed the investigation level do not require further investigation.

Geometry effects (e.g., intersections of concrete floors and walls) or differing material types may contribute to investigation level exceedances and will be considered in determining what, if any,

further investigations are warranted. These contributions and the conclusions regarding their impact will be documented as part of the investigation. Depending on the results of the investigation, the survey unit may require remediation, reclassification, and/or resurvey.

5.7.1 Investigation Levels

Investigation levels, listed in Exhibit 5-5, are specific levels of radioactivity used to indicate when additional investigation may be necessary. They represent values above which, when coupled with measurement uncertainty, suggest further investigation may be warranted. Investigation levels also serve as a QC check. For example, in addition to indicating potential contamination, a measurement that exceeds the investigation level may indicate an improperly classified survey unit or a failing instrument, at which point the survey unit may be reclassified or the instrument will be recalibrated, if needed.

Exhibit 5-5. Investigation Levels

Survey Measurement	Investigation Level
Contiguous Static Measurements	0.75 x remediation goal
Smear Samples	0.75 x remediation goal
Gamma Scans	z-score > 3 sigma
Soil (or Volumetric) Samples	0.75 x remediation goal

5.7.2 Remediation

Areas where the ~~average~~ residual radioactivity exceeds the remediation goal will be remediated to reduce elevated radioactivity to acceptable levels (see Sections 7.0 and 8.0), and the areas will be resurveyed. Based on resurvey data, it may be deemed necessary to remediate all or a portion of a survey unit.

5.7.3 Reclassification

If survey measurements in a Class 2 or Class 3 survey unit suggest a reasonable potential that contamination is present in excess of the remediation goals, the survey unit will be reclassified as a Class 1 survey unit. A Class 2 or Class 3 survey unit which requires remediation will be reclassified as a Class 1 survey unit.

In certain situations such as in small, localized areas, the survey coverage area of the survey unit containing the elevated measurements may be separated out into a new survey unit and reclassified based on the following:

- The basis for the original survey unit classification,
- The postulated cause of the elevated residual radioactivity,
- The possibility for other similar areas within the original survey unit having gone undetected; and
- The extent of the elevated radioactivity (and corresponding remediation) relative to the total area of the original survey unit.

Where the survey coverage area containing the elevated measurements is localized and can be separated out into a new survey unit, the remainder of the original survey unit will retain its original classification. If the survey results indicate extensive elevated measurements, the entire survey unit will be reclassified as prescribed in the preceding paragraph.

5.7.4 Resurvey

If a survey unit is reclassified or if remediation activities are performed, then a resurvey using the methods and frequency appropriate for the new survey unit classification will be performed.

~~Note that if remediation is not performed, For example, changing the classification of a Class 2 survey unit to Class 1 entails increasing survey coverage to 100 percent of the surface area. A complete resurvey of a Class 2 survey unit reclassified as determined to be a Class 1 survey unit does not require a complete resurvey; however, the is not necessary provided remediation is not performed survey coverage must be increased to 100 percent of the accessible surface area.~~

In the case where a new survey unit is separated out from an existing survey unit or an existing survey unit is subdivided, Class 3 survey units need only additional randomly located measurements to complete the survey data set. Class 1 and Class 2 survey units require a new survey design based on random-start systematic measurement locations. ~~Survey coverage will be modified appropriate to the survey unit classification.~~

Where a small fraction of the area of a Class 1 survey unit is remediated, a resurvey of only the remediated area will be performed. These replacement survey measurements will be performed over 100 percent of the remediated area.

5.8 REFERENCE AREAS

Establishing background radionuclide concentrations is necessary to identify and evaluate residual radioactivity attributable to legacy Navy operations at HPNS. Certain radionuclides may occur at significant levels as part of background in the media of interest (e.g., concrete, tile, soil). Examples include members of the naturally occurring uranium, thorium, and actinium series. Cs-137 and other radionuclides are also present in background.

A reference area will be applied when one or more radionuclides of concern are present in background at levels that are more than a small fraction (e.g., one-third) of the remediation goal. The reference area should ~~be radiologically non-impacted and~~ have physical, chemical, geological, ~~radiological,~~ and biological characteristics similar to those of the survey unit being evaluated. Reference areas ~~normally~~ are selected from non-impacted areas, but are not limited to natural areas undisturbed by human activities. In some situations, a reference area may be associated with the survey unit being evaluated, but it cannot be potentially contaminated by site activities. Reference areas provide a location for background measurements, which are used for comparison with survey unit data. Ideally, the radioactivity present in a reference area would be the same as the radioactivity present in the survey unit had it never been contaminated.

Reference area data sets will be qualified for use in performing quantitative and statistical analyses. The qualification process includes assessing the data using numerical and graphical methods to verify they are statistically independent, symmetrical (though not necessarily normal), and that there are no trends in the data that would disqualify their use.

Reference areas identified by previous site contractors are discussed in the following subsections. The reference areas will be qualified and, if suitable, used to develop representative radionuclide background concentrations. If they are not found to be suitable, new reference areas having physical and radiological characteristics similar to those of the impacted area(s) being evaluated will be identified. Reference area data will be collected, evaluated for suitability, and presented to the Navy for concurrence prior to its use.

5.8.1 Building Surfaces

Building 400 was constructed in a similar era and is comparable in its variety of interior surfaces to Buildings 211 and 253 (see Figure 1). This building also had construction materials similar to Buildings 211 and 253, and was not listed as radiologically impacted in the HRA (NAVSEA 2004). Reference area data sets were collected from the building and used to assess data collection during the 2013 radiological characterization of the buildings (reference TtEC, 2017a and 2017b). For this project, new reference material background data sets will be developed and qualified as needed.

5.8.2 Soil

An area near Ship Berth 29 in Parcel D-1 (see Figure 1) has been used as a soil reference area because its surroundings, vegetation, and overall topography are similar to those at Buildings 211 and 253 and because it has no history of radiological use (TtEC, 2017a). Based on the results of the reference area survey, the Ra-226 background contribution was assumed to be 0.375 pCi/g. This background contribution was considered in Ra-226 sample concentration comparisons to the release criteria, including dose and risk modeling assessments. No background contribution was assumed for Cs-137, Sr-90, or Pu-239. Th-232 was not assessed. The Navy will work with the BRAC Closure Team (BCT) to develop a more representative background value for Ra-226 concentration in soil in the event soils of different types or origins are encountered.

6.0 SURVEY PREPARATION

Appropriate authorizations will be obtained and notifications made prior to mobilization. Once mobilized, the initial task will be to perform a radiological survey of the both buildings, including the outside building perimeter areas, to: (1) identify existing radiological hazards, and (2) ensure radiological controls appropriate to those hazards are instituted. Walk-downs will be used to assess the physical state of each survey unit and the scope of work necessary to prepare the survey unit for remediation and survey. Work packages will be prepared detailing the work to be performed, the sequence of activities, and the work controls to be applied. As remediation and survey activities are completed, survey units will be isolated and access to the survey units will be controlled to minimize the potential for radioactive cross-contamination from ongoing remediation activities in nearby areas.

6.1 AUTHORIZATIONS AND NOTIFICATIONS

The Navy complies with the substantive requirements of applicable and relevant permits. Necessary authorizations will be obtained from the ROICC and the CSO for implementing and completing the work. The appropriate Navy personnel, including the RPM, RASO, and the CSO will be notified regarding the planned schedule prior to mobilization. On-site activities (i.e., personnel and equipment mobilization) will begin once notice to proceed is received from the Navy.

6.1.1 Radioactive Material License

Since field work will occur within the portion of HPNS under NRC jurisdiction, the NRC was notified by letter dated April 12, 2017, of Gilbane's intent to initiate license activities at HPNS. There are no plans to implement the State of California license at this time since no field work is planned within the portion of HPNS under California jurisdiction.

The existing memorandum of understanding between Gilbane and other radioactive material licensees working at HPNS was revised on April 10, 2017, to ensure proper interfacing of radioactive material handling responsibilities.

6.1.2 State Historical Preservation Office Letter

A letter to the California Office of Historic Preservation (OHP) will be prepared detailing the process that will be used to access, survey, and sample the SSSD lines and surrounding soil. The letter will provide background information including the environmental and archeological setting and describe how the field work activities will be ~~monitored~~ performed in accordance with guidance provided in the *Basewide Radiological Archaeological Monitoring and Discovery Plan, Hunters Point Naval Shipyard, San Francisco County, California* (King, 2012) and that the field work is not expected to have adverse archeological effects. OHP concurrence that there are no adverse archeological effects will be obtained before excavation begins in archaeological zones. The letter will be reviewed by the Navy prior to submittal to the OHP.

6.2 RADIOLOGICAL CONTROLS

A radiological survey of both buildings, including the outside building perimeter areas, will be performed to ensure that radiological controls, posting, maintenance, dust mitigation, air monitoring, and other measures appropriate to control/mitigate contamination are instituted prior to the commencement of building remediation and SSSD line removal activities. Radiological controls will be modified as necessary to support ongoing building remediation and SSSD removal activities.

~~Based on contamination survey results,~~ Radiologically controlled areas (RCAs) will be established where contamination exists and where contaminated M&E are handled, characterized, and stored for disposal. Work activities within an RCA will be conducted in accordance with a radiation work permit that details the radiological requirements and protective measures to be applied to the job ~~(see RMWMP in Appendix C)~~. Contaminated M&E will be wrapped (or other measures used to capture and contain contamination), dismantled, removed, and/or moved intact to the extent possible.

Work involving cutting, drilling, grinding, or scabbling on contaminated building surfaces or materials will be performed inside a posted contamination area. Contamination areas will be located within a larger RCA to ensure sufficient radiological controls are in place. Ventilation systems and containment devices (e.g., glove boxes, containment tents, catch basins) will be used for work involving high levels of localized contamination, to control the movement of airborne

radioactivity and prevent or minimize the spread of contamination. A higher level of contamination control will be instituted for openings in drains, vents, or exhaust stacks, which may be bagged, capped, or sealed and negative pressure applied using high-efficiency particulate air (HEPA) filtered vacuums while work on the component is performed. Removed M&E will be surveyed for loose contamination, and then delivered to the designated material handling area. Once removal and/or remediation activities are complete, the posted work area will be decontaminated as needed, surveyed, and down-posted.

6.3 WALKDOWN

Walkdowns of each survey unit will be performed to assess the physical state of survey unit and the scope of work necessary to prepare it for remediation and survey. During the walkdown, requirements for accessing, isolating, and controlling the survey unit will be identified. Support activities necessary to conduct the survey and any required removal/remediation, such as scaffolding, interference removal, and electrical tag-outs, will be identified. Safety concerns such as access to confined spaces, high walls, and ceilings also will be identified.

The following items will be considered during the walkdown, as appropriate/applicable:

- Planned physical work in, on, or around the survey unit and its potential to create/spread radioactive contamination;
- Needed housekeeping, clean-up, and remediation of the survey unit;
- Scaffolding, temporary electrical and ventilation equipment and components, and other material or equipment needed to support survey and remediation activities;
- Appropriate measures needed to prevent the introduction of radioactive material into the survey unit once remediation activities are complete; and
- Measures to control access and egress and otherwise restrict radioactive material from entering the survey unit.

6.4 WORK PACKAGE PREPARATION

Once a walkdown of a given survey unit has been performed, a survey unit work package will be prepared that details the work to be performed, the sequence of activities, and the work controls that will be applied. The work package will include:

- Survey unit description and boundaries, classification, and surface and material type(s);

- Summary of known information, including previously collected radiological survey and sampling data, and issues/concerns regarding areas of potential contamination;
- Planned M&E removal, including justification for M&E to remain, as appropriate;
- Nature and extent of remediation to be performed, including planned remediation methods; and
- Post-remediation radiological survey and sampling to be performed, including survey coverage and type, number, and spatial distribution of measurements/samples.

An example survey unit work package format is found in Appendix G. The presentation and content of the work package will be refined in coordination with the Navy.

Changes to the initial survey unit design (e.g., classification, configuration, size, measurements, etc.) may be made prior to the start of data collection in the survey unit, consistent with the work package preparation process above. Changes in classification will be based on survey data and other available information that indicate another classification is more appropriate.

As a general rule, a separate work package will be prepared for each individual survey unit; however, several logically grouped survey units may be combined into a single work package where appropriate to facilitate work activities. Work packages will be developed as the project progresses in order to incorporate lessons learned and updated information from field assessments. Completed work packages will be submitted to the Navy for review and concurrence before remediation and survey activities begin in the individual survey unit.

6.5 ISOLATION AND CONTROL

Survey units where survey and remediation activities are complete will be isolated and access controlled to minimize the possibility that radioactive material will be re-introduced into the survey unit from ongoing remediation activities in nearby areas. Routine access, equipment removal, material storage, and worker and material transit through the survey unit will not be allowed.

6.6 HOUSEKEEPING

Routine clean-up will be performed as needed to keep the buildings, site, and adjacent properties free from accumulations of waste materials, rubbish, and windblown debris. Sidewalks and

DRAFT Work Plan
Parcel C Buildings 211 and 253 Radiological Remediation
Hunters Point Naval Shipyard, San Francisco, California

streets, especially common areas, affected by the work will be swept clean and returned to a condition that is acceptable to the ROICC and CSO.

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7.0 BUILDING SURVEY AND REMEDIATION

In order to achieve the radiological release of Buildings 211 and 253 to unrestricted use, a series of surveys will be performed to identify or confirm the existence of radioactive contamination, delineate the scope of remediation, guide remediation activities as they are performed, and either confirm the success of the remediation or identify areas requiring further remediation.

The survey and remediation process will follow a defined work sequence on a survey unit-by-survey unit basis to minimize the potential spread of contamination. Contaminated vertical and suspended drain piping will be removed, followed by the remediation of contaminated surfaces, including localized areas on the floors, walls, and structural columns. Contiguous static measurements will be performed and smear samples collected in accordance with the survey design to detect and quantify total and removable alpha/beta surface radioactivity on building surfaces.

7.1 WORK SEQUENCE

As a general rule, survey and remediation will be performed using a top-down, highest-to-lowest approach, i.e., from the top floor down to lower floor levels and from areas of highest contamination to lowest (a “worst first” approach), to minimize the potential spread of contamination. Surveys and remediation will generally be conducted by floor, beginning in Building 253 on the 6th floor and working down to the ground floor. The Building 211 ground (or main floor) will be surveyed last. This approach will allow the work of other contractors within Building 253 on the ground floor to continue without impacting building survey and remediation until the later stages of the fieldwork activities, by which time the work of the other contractors should be complete.

Scaffolding and other temporary equipment or material needed for survey and/or remediation will be installed. Once remediation is satisfactorily completed, housekeeping and clean-up activities will be performed. Tools, equipment, and materials not needed for survey data collection will be removed. Survey data will be collected and analyzed to determine if further remediation is required. Additional remediation will be performed as needed and post-remediation survey data collected.

7.2 REMOVAL OF CONTAMINATED MATERIALS AND EQUIPMENT

Contaminated vertical and suspended drain piping within Buildings 211 and 253 will be removed. Areas in Building 211 that could not be surveyed previously due to structural safety concerns will be reinforced and surveyed. M&E not previously surveyed also will be surveyed. Contaminated M&E, including that currently stockpiled in the buildings, will be removed. Installed equipment identified as contaminated, such as the electrical panels, racks, ventilation ductwork, and drain piping, will be removed. Remaining equipment such as motors and blowers that cannot be properly surveyed due to inaccessible surfaces also will be removed. Contaminated M&E will be wrapped to prevent the spread of contamination and disposed as LLRW by the basewide LLRW disposal contractor. Radioactive materials and waste management are addressed in the RMWMP (see Appendix C).

7.3 SURFACE REMEDIATION

Contaminated rooms and building surfaces, such as localized areas on the floors, walls, and structural columns, will be remediated. Non-destructive methods such as surface wipe-down are preferred. If non-destructive methods are ineffective, localized remediation will be performed using more aggressive means such as scraping, using a needle gun with a HEPA vacuum, or cutting out and removing the material. The selection of methods used for localized remediation will consider the impact on the surface efficiency values based on the as-left condition of the surface once the remediation is completed.

Remediation will be conducted so that it does not affect the structural integrity/stability of the building. For example, it may be necessary to replace small areas of the floor if removed due to contamination, or to reinforce the floor from below (if on other than the ground floor) to ensure stability. No load-bearing walls or structural elements will be compromised or removed.

7.4 CONTIGUOUS STATIC MEASUREMENTS

Contiguous static measurements will be performed to detect and quantify alpha/beta surface radioactivity on building surfaces. Contiguous static measurements are neighboring measurements of surface radioactivity that share proximity in both space and time (i.e., they are collected spatially near one another and at about the same time), with each measurement performed at a discrete location for a fixed count time.

7.4.1 Methodology

The process outlined in MARSSIM (DoD et al., 2000) relies on scanning to provide a qualitative level of confidence that no areas of elevated residual radioactivity (i.e., radioactivity above the remediation goals) remain (e.g., areas that may have been missed by static measurements collected from across a survey unit). However, contiguous static measurements will be performed instead. A technical basis for using contiguous static measurements in lieu of scanning is found in Appendix H.

Contiguous static measurements will be performed using an array of six Ludlum Model 43-37-1 821 cm² gas-flow proportional detectors coupled to a Ludlum Model 4612 12-channel counter. The six Ludlum Model 43-37-1 detectors are mounted side-by-side lengthwise in a 3 x 2 configuration on a frame measuring approximately 58 cm by 136 cm. The detector array is placed on the surface to be measured and a count is collected. Twelve individual counts – two per detector (one alpha and one beta) – are captured along with a date/time stamp for each count. The detector array is then moved to the next measurement location and the process repeated until contiguous statics have been collected across the entire survey coverage area. A system of surface markings and map notations will be used to capture the position of each measurement location within the building.

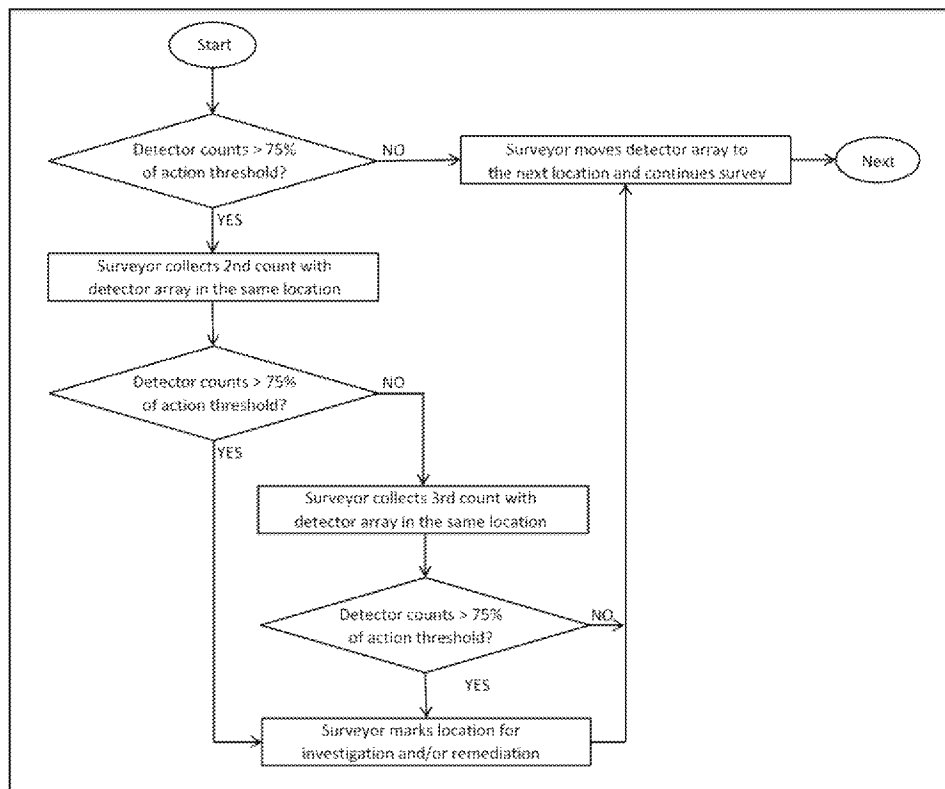
If any detector registers counts exceeding the investigation level, it is flagged and surveyed two more times. Locations where the detector counts exceed the investigation level 2 of out 3 times will be marked for further assessment and/or remediation according to the 2-out-of-3 logic shown in Exhibit 7-1.

7.4.2 Effective Survey Coverage

The detector array covers a surface area of approximately 1.0 m². However, approximately 40 percent of the surface area covered by the detector array is outside a detector window (i.e., active area). In other words, 60 percent of the surface area covered by the detector array is within the active area of a detector. So, taking measurements at a sequential spacing of one detector array-width results in an effective survey coverage of 60 percent. That is more than sufficient coverage for a Class 2 survey unit that only requires 50 percent coverage, but insufficient for a Class 1 survey unit, which requires 100-percent survey coverage. To achieve

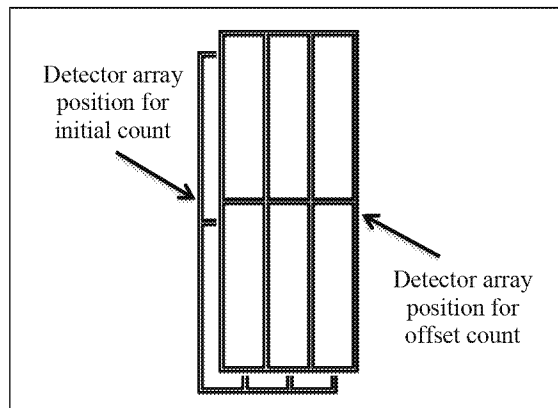
100-percent survey coverage, the detector array is moved to an offset position so that surface areas originally missed are now covered, as shown in Exhibit 7-2, and a second count is performed. The process is then continued by moving the detector array over one array-width and repeating the two-step count process.

Exhibit 7-1. Diagram Showing 2-Out-of-3 Logic



Since a survey coverage of 60 percent is provided by the detector array itself, a higher survey coverage is achieved by overlapping the detector array positions, as illustrated in Exhibit 7-2. A lower survey coverage, which may be appropriate for a Class 2 or Class 3 survey unit, is achieved by increasing the spacing between detector array positions for each subsequent measurement.

Exhibit 7-2. Detector Array Offset to Achieve an Effective Scan Coverage of 100 Percent



7.4.3 Equivalent Static Measurements

The process described in MARSSIM (DoD et al., 2000) relies on a statistically significant number of static measurements collected from both random (Class 3) and systematically-spaced (Class 1 and Class 2) locations to demonstrate residual radioactivity is below the remediation goals. Typically this results in 10 to 30 static measurement locations per survey unit. Contiguous static measurements not only will be used in lieu of scanning, but also will be used as static measurements to demonstrate residual radioactivity is below the remediation goals, since they are discrete measurements performed at finite locations.

The detector array yields measurement results for a total of six equivalent static measurement locations – one per detector – over each approximate 1.0 m² surface area, which are fixed positions within the detector array. The random or systematic grid spacing dictates where the detector array is positioned.

7.4.4 Small Area Coverage

A single Model 43-37-1 detector will be used to perform contiguous static measurements in small or tight areas where the detector array cannot be used effectively (e.g., ledges, corners,

irregularly shaped surfaces). The same measurement methodology, including the detector offset method, will be used where the survey coverage requirement is greater than 60 percent.

7.5 SMEAR SAMPLES

Smear samples will be collected to detect removable alpha/beta surface radioactivity on building surfaces. A single smear sample will be collected randomly within the spatial footprint of the detector array at each contiguous static measurement location.

Smear samples will be collected over approximately 100 cm² and analyzed for alpha and beta radioactivity using a Protean WPC 9550 gas-flow proportional alpha/beta counting system (or equivalent), using a count time of one minute or longer to meet the required MDC. In lieu of using a Protean WPC 9550, field counting of samples may be performed using a Ludlum Model 43-10-1 dual phosphor scintillation detector with a Ludlum Model 2929 alpha/beta scaler (or equivalent). Data will be reported in units of dpm/100 cm² or dpm/smear.

8.0 SANITARY SEWER AND STORM DRAIN REMOVAL

The *Final Basewide Storm Drain and Sanitary Sewer Removal Plan, Hunters Point Naval Shipyard, San Francisco, California* (TtEC, 2012) forms the basis for the SSSD removal, survey, and related sections of the SAP (Appendix A). The removal of the remaining SSSD lines shown on Figure 2 will be performed in segments, though more than one segment may be worked simultaneously. The general approach to each segment will be to remove the overlying concrete (or asphalt), excavate the soil, and remove the piping. A survey of the excavated trench surfaces will be performed and remediation performed (as necessary). On a parallel path, the soil removed during trench excavation will be transported to a radiological screening yard (RSY; Figure 1), screened for discrete radioactive objects, and characterized for disposal. Imported material will be used to backfill the open trench once Navy concurrence is received. Imported material will be tested and the results submitted to the Navy for approval prior to it being brought on site and used to complete backfill operations.

The removal and survey process is designed to be executed largely without trench entry, but will use trench boxes or shoring to ensure safety when entry is required. Other safety precautions include monitoring for non-radiological chemicals of concern (e.g., volatile organic compounds) during intrusive soil activities in accordance with the APP/SSHP. The results will be used to evaluate the need for additional engineering controls, work practices, and/or PPE.

8.1 UTILITY CLEARANCE

Underground utility clearance will be completed before intrusive activities are initiated, and include:

- Review of utility maps, including historical maps from previous work;
- Use of geophysical methods, including electromagnetic induction, magnetometry, and ground-penetrating radar, to clear the proposed limit of intrusive activity of potential subsurface obstructions prior to soil excavation or saw-cutting;
- Marking of the proposed limits of intrusive activity and the utility lines in the immediate vicinity, using color-coded surveyor paint;
- Notifying Underground Service Alert North; and
- Scheduling a meeting with all interested parties that may be affected by excavation activities.

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Utilities will be identified, excavated around to the extent possible, and supported or shored, as required, to ensure integrity.

8.2 TRENCH EXCAVATION

The overlying building slab (interior) or durable cover (exterior) concrete and/or asphalt will be saw-cut out from the area to be excavated, direct-loaded into trucks, and transported to a temporary storage area to be radiologically screened for re-use or disposal. Where possible, each trench segment excavation will begin at a known origin, access, or termination point to verify that piping is present and can be followed. Trench excavation will continue to former termination points so that no known SSSD lines remain. The soil overlying the SSSD lines will be excavated, direct-loaded into trucks, and transported to the RSY to be screened and characterized for disposal. Soil will be removed to a minimum of 0.3 m below and to the sides of each pipe.

8.3 REMOVAL OF SANITARY SEWER AND STORM DRAIN PIPING

After the soil is excavated from around the SSSD line and transferred to the RSY for processing, the piping will be removed from the trench. To the extent practicable, the piping will be removed intact, capped and wrapped to contain silt and debris that may be inside the piping, and moved to a temporary laydown area. Components that disintegrate or crumble during removal will be transferred along with the surrounding soil to the RSY for processing. Piping greater than 15 cm in diameter, along with non-soil material, and suspected contaminated soil that may be encountered during excavation will not be sent to the RSY. Instead, piping of that size will be handled within an RCA, to be disposed as LLRW or held until survey and sampling data demonstrate it may be handled in another manner. During transport of SSSD lines, trucks and truck routes will be screened for radioactivity in compliance with the RMWMP (Appendix C) and the RPP (Gilbane, 2018b).

8.4 NON-SOIL MATERIALS

Concrete, asphalt, piping, and debris, if any, will be surveyed in accordance with the RPP at a temporary storage area controlled as an RCA. If found to be radioactively contaminated, the material will be handled in accordance with the RMWMP (see Appendix C).

8.5 TRENCH SURVEY AND SAMPLING

Survey and sampling of the excavated trench surfaces will be performed once soil excavation and pipe removal are complete. Trench segments will be combined into survey units not to exceed 2,000 m² in total surface area (trench floor and sidewalls). Survey and sampling results will be assessed. Locations with radioactivity that exceeds the investigation level will be investigated (see Section 5.7) and remediated (i.e., excavated) as appropriate. Post-remediation survey and sampling will be performed to verify the remediation goals are met.

8.6 RADIOLOGICAL SCREENING OF EXCAVATED SOIL

Soil excavated during trench excavation activities will be transported to an RSY built on the Building 224 concrete pad, where the soil will be radiologically screened and characterized prior to disposal. Soil entering the RSY will be tracked through the screening process to ensure its return to the area from which it was excavated.

Screening pads will be constructed with 10-mil plastic sheeting placed on the ground surface and wrapped over hay bales placed around the perimeter of the laydown pad to form a containment area to prevent run-off and run-on during precipitation events. A sacrificial layer of soil will be laid down on top of the sheeting to protect it during soil handling activities. A gamma scan of the constructed pad will be performed prior to use to establish baseline radiological conditions and to assure that there are no radiation anomalies that may impact its use. Radiological controls, posting, maintenance, dust mitigation, air monitoring, and other measures appropriate for the RSY operation will be instituted. Air particulate monitoring will be conducted at upwind and downwind locations when potential dust generation activities are occurring (e.g., aeration of soil, mechanical soil screening, and soil relocation).

The soil will be spread out onto screening pads in lifts approximately 15-20 cm thick to be radiologically screened for discrete radioactive objects. Following screening, waste characterization samples will be collected in accordance with the SAP (see Appendix A). The soil will then be stockpiled and staged for off-site disposal. Stockpiled soil will remain separate and segregated (i.e., each stockpile will consist of soil from a single screening on a given screening pad) from other screened soil to retain data integrity and ensure there is no cross-contamination. Environmental protection measures (e.g., runoff/erosion control) will be

implemented and maintained in accordance with the Environmental Protection Plan (see Appendix D) while the soil is stockpiled. Soil will be handled in accordance with the RMWMP (see Appendix C).

8.7 GAMMA SCANS

Gamma scans of excavated trenches and soil will be performed to locate radiation anomalies (i.e., irregularities) that might indicate areas of elevated discrete or distributed radioactivity that warrant further investigation. Gamma scans will be performed over 100 percent of the surface area of the excavated trench or soil on the screening pad.

Gamma scans will be performed using a Radiation Solutions, Inc. (RSI) RS-700 self-contained mobile gamma-ray detection system. The RS-700 consists of a digital gamma-ray spectrometer/multi-channel analyzer coupled to a 10-cm by 10-cm by 40-cm sodium iodide (NaI) gamma scintillation detector. Custom-built copper-lined lead shielding with a steel surround encases the top and sides of the detector. The shielding focuses the detection capability on radiation coming from the ground – i.e., it forces the detector to “scan downward,” optimizing the detection of gamma-rays at surface or near-surface locations.

8.7.1 Physical Configuration

The RS-700 system is mounted on a small tractor to enable survey of spread-out soil on a screening pad, or mounted either vertically or horizontally on an arm extending from a man-lift to enable survey of the trench floor and walls, respectively. The RS-700 automatically captures gamma scan data at one-second intervals and position-correlates the data by means of a global positioning system (GPS) mounted to the unit. Pre-set multiple independent regions of interest within the energy spectrum programmed into the RS-700 identify and track specific gamma-ray emissions from the radionuclides of concern and/or their gamma-emitting progeny.

The detector is mounted at a height of 10 cm above the surface and moved over the surface at a speed of 0.5 meters per second (m/sec), with each pass spaced approximately 0.5 m from the previous pass (center line to center line) to assure 100-percent coverage of the area being surveyed. Changes to the scan height or scan rate may be made to improve detection response if necessary to accommodate field conditions, such as soil composition, and moisture content.

Smaller areas that cannot be surveyed using the RS-700 system will be scanned using a hand-held Ludlum Model 44-10 5.1-cm by 5.1-cm NaI gamma scintillation detector with a Ludlum 2221 rate meter/scaler (or equivalent). The survey data collected will be documented on a survey map. The detector position and scan speed used for the RS-700 also will be used for the Ludlum 44-10.

8.7.2 Contour Mapping

Contour maps will be created using the RS-700 data to aid in field investigations as well as to facilitate the selection of biased measurement locations. The mean and standard deviation of the dataset will be calculated and used to develop color-coded contour maps based on z-score values (i.e., the number of standard deviations each measurement lies from the mean). The contouring process involves creating a regularly spaced grid and assigning values to every spot on the grid. Grid node values will be assigned using a weighted average based on the inverse square law, which describes how radiation levels drop off with distance from a source. Once the grid is complete, color-coded contours will be created from grid node values within the specified ranges of values. The contouring process tends to smooth over single data points with lower sigma values while accentuating clustered areas or single locations with higher sigma values. This aids in the data analysis by focusing attention on those areas most likely to contain discrete radioactivity.

8.8 SOIL SAMPLES

Soil (i.e., volumetric) samples will be collected from the excavated trenches to quantify concentrations of radionuclides of concern. Samples will be collected at a frequency and at representative locations throughout the survey unit such that a statistically sound conclusion regarding the radiological condition of the survey unit can be developed. The frequency (i.e., number of samples) is described in Section 8.8.1. The method by which representative samples locations are selected is described in Section 8.8.2. A minimum of 20 samples per survey unit will be collected for radiological analysis.

Except where available material to sample is limited, samples collected will be approximately 1,000 grams in size. Visually identifiable foreign objects and debris will be separated manually in the field. Sampling equipment (e.g., hand and power tools, mixing utensils, and

homogenizing bowls) will be decontaminated (using dry methods) between samples to prevent cross-contamination of sample media. Samples will be double-bagged in one-gallon resealable plastic bags, numbered, logged, and sent for laboratory analysis. Each sample will be labeled and assigned a unique sample identification number.

8.8.1 Number of Samples

The method for determining the number of samples necessary to assure a population of sufficient size for statistical analysis was utilized in accordance with MARSSIM Section 5.5.2.2. The method defines a gray region as the range of uncertainty regarding the true mean of the sample population. The width of the gray region is the difference between the upper bound of the gray region (UBGR) and the lower bound of the gray region (LBGR). Setting the background contribution to zero, the LBGR can be set equal to zero and the UBGR set equal to the remediation goal. The concentration to be measured relative to the variability in the concentration determines the number of samples needed. The ratio is referred to as the relative shift, denoted by Δ/σ .

Equation 8-1

$$\Delta/\sigma = \frac{UBGR - LBGR}{\sigma}$$

where:

UBGR = upper bound of gray region (= remediation goal)

LBGR = lower bound of gray region (= 0)

σ = standard deviation or variability in the measured concentrations

MARSSIM (DoD et al., 2000) states that relative shift values greater than 3.0 will not result in significant changes in the number of samples required to support a decision. Based on the above, 20 samples is a statistically sufficient number of samples to support a decision. This assumes Based on a relative shift (Δ/σ) of 1.43-0 and false positive and false negative decision error rates (i.e., Type I (α) and Type II (β), respectively) of 0.05 (i.e., 95 percent confidence level). MARSSIM Tables 5.3 and 5.5 provide the number of samples required to support a decision using one of two statistical tests (see Section 9.4). Exhibit 8-1 gives the required number of

samples for selected relative shift values for Type I (α) and Type II (β) decision errors of 0.05 each.

Exhibit 8-1. Required Number of Samples

Relative Shift (Δ/σ)	Statistical Test	
	Sign	WRS
1.5	18	18
2.0	15	13
2.5	15	11
3.0	14	10

As illustrated in Exhibit 8-1, regardless of the statistical test applied, using 20 as the minimum number of samples provides a statistically sufficient number of samples to support a decision.

8.8.2 Sample Locations

For Class 1 and Class 2 survey units, a random-start systematic pattern will be used to identify sample locations. The starting point will be determined by a random selection process, and successive sample locations will be distributed around the starting point in a systematic pattern across the survey unit. Samples in Class 3 survey units will be taken at random locations. Up to five samples also will be collected at biased locations identified for further investigation by gamma scans. This ensures that data are collected from suspected areas that might otherwise be missed through the systematic sampling process, and provides a better indication of the maximum concentrations of radionuclides of concern that are present.

8.8.3 Supplemental Samples

Volumetric samples of concrete or other materials may be collected in accordance with the SAP (Appendix A) for laboratory analysis where volumetric radioactivity is suspected to be present and/or additional qualitative information regarding its form and/or isotopic composition is desired.

8.9 SAMPLE ANALYSIS

Samples will be turned over to a laboratory accredited under the DoD Environmental Laboratory Accreditation Program and the California State Environmental Laboratory Accreditation Program, using proper chain-of-custody procedure. Once received by the laboratory, samples will be prepared by drying, grinding, mixing, sifting, and weighing as appropriate prior to

analysis in accordance with the SAP (see Appendix A). Radiological data will be reported in pCi/g dry weight, along with estimated total propagated uncertainty and MDC.

8.9.1 Cs-137 and Ra-226 Analysis

Samples will be analyzed by gamma spectroscopy for Cs-137 and Ra-226. The concentration of Ra-226 will be inferred from the concentration of its progeny bismuth (Bi)-214 using a progeny in-growth method to allow the Bi-214 to approach secular equilibrium with Ra-226. The method requires the sample to be hermetically sealed with a 21-day (or longer) hold time before counting. The Ra-226 results will be calculated and reported from the 46.1 percent abundant 0.609 MeV gamma spectrum line of Bi-214 after the in-growth period of 21 days.

8.9.2 Sr-90 Analysis

A minimum of 10 percent of the samples will be randomly selected for analysis by gas proportional counting for total strontium. In addition, samples for which gamma spectroscopy results indicate the presence of Cs-137 above its remediation goal also will be analyzed for total strontium. If the total strontium result does not exceed the remediation goal, then no further analyses will be performed. Otherwise, Sr-90 analysis will be performed to quantify the Sr-90 concentration.

8.9.3 Pu-239 Analysis

If the analytical results exceed the Cs-137 or Sr-90 remediation goals, the sample will be analyzed by alpha spectroscopy for Pu-239. Both Cs-137 and Sr-90 are fission products. Their presence in the environment is not unexpected due to global fallout from the atomic bomb testing era. However, their presence above the remediation goals may suggest the possible presence of additional non-naturally occurring radionuclides such as Pu-239.

8.9.4 Th-232 Analysis

The concentration of Th-232 will be inferred from the concentration of its progeny actinium (Ac)-228 reported by gamma spectroscopy. Th-232 can be considered to be in secular equilibrium with Ac-228 due to the relatively short half-lives of its progeny Ra-228 and Ac-228, which are 5.8 days and 6.1 hours, respectively. If the Th-232 result based on Ac-228 does not exceed the remediation goal, then no further analyses will be performed. Otherwise, the sample will be analyzed by alpha spectroscopy for Th-232 to quantify the Th-232 concentration.

8.10 BACKFILL AND RESTORATION OF SITE CONDITIONS

Once remediation is complete and the Navy concurs, excavated trenches will be backfilled.

Imported backfill material will meet the requirements found in the *Backfill Acceptance Plan, Installation of Durable Covers in Parcel C, Hunters Point Naval Shipyard, San Francisco, California* (TtEC, 2015).

Backfill material will be placed into excavated trenches and compacted, and the surface will be restored to conditions that are compliant with the specifications of the durable cover in accordance with the *Final Remedial Design and Design Basis Report for Parcel C, Hunters Point Shipyard, San Francisco, California* (Kleinfelder CH2M Hill Joint Venture [KCH], 2012).

Where groundwater is present, recycled concrete (reduced to less than 0.3 m diameter for re-use), and/or rock/gravel will be placed as bridging material, depending on the water level.

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9.0 WASTE CHARACTERIZATION AND DISPOSAL

Soil removed from the Building 211 and 253 trenches will be characterized and either recycled/reused or disposed of at one or more approved off-site landfills, as appropriate. Samples will be collected and analyzed for both chemical and radiological waste profiling before the waste is taken off site. All waste management and disposal practices -- including dust control, truck tarping, and air monitoring - will be performed according to the Dust Control Plan (DCP) which is part of the Environmental Protection Plan (EPP - Appendix D). All sampling will be performed according to the SAP (Appendix A).

Debris (rocks, concrete, rebar, metal debris, wood, and other refuse) will be screened radiologically by sodium iodide (NaI) detectors as described in Section 8.7 of the RAWP and, if found to produce elevated gamma activity, will be classified as LLRW and placed into a bin provided by the basewide radiological disposal contractor. Testing requirements for debris may vary depending on the material, but could include testing for hazardous characteristics required under RCRA or testing for requirements of the disposal facility. Radiologically cleared debris that is recyclable or reusable (e.g., metal, concrete, asphaltic concrete) will be recycled off site or retained for reuse on site. All other radiologically cleared debris will be disposed by Gilbane.

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Following radiological screening, laboratory characterization, and concurrence from the Navy, all soil identified as LLRW will be loaded into sealable roll-off bins to be requested by Gilbane and provided by the Navy's Waste Broker. The Waste Broker is responsible for LLRW transport and disposal. Soils removed as a result of radioactive material removal will be placed in a package in accordance with Department of Transportation (DOT) regulations, as specified in Title 49 CFR Subpart I, and will be stored in a designated and posted radiological material storage area for characterization and subsequent disposal by the HPNS Waste Broker under the direction of the Navy LLRW Disposal Program. If more extensive radiological and/or chemical contamination is found, additional waste packaging requirements will be considered in coordination with the Navy BRAC RPM and RASO.

9.010.0 SURVEY DATA ASSESSMENT

Survey data will be reviewed to verify that they are authentic, appropriately documented, and technically defensible. Direct comparison of the survey data to the remediation goals will be performed. Survey data will be graphed to identify patterns, relationships, or potential anomalies in the data that might go unnoticed using purely numerical methods. ~~Where one or more measurements exceed the remediation goal, either the Sign or WRS statistical test will be applied~~ and conclusions drawn from the data as to whether the survey unit meets the remediation goals.

Dose and risk levels for the critical group will be derived by analyzing actual residual radioactivity using exposure scenarios modeled using RESRAD-ONSITE (formerly known simply as RESRAD) and RESRAD-BUILD.

9.110.1 DATA VALIDATION AND VERIFICATION

The review criteria for data acceptability are as follows:

- The instruments used to collect the data are capable of detecting the radiation types and energies of interest at or below the remediation goals.
- The calibration of the instruments used to collect the data is current, and the radioactive sources used for calibration are traceable to the National Institute of Standards and Technology.
- Instrument ~~response performance~~ is checked before instrument use each day.
- The MDCs and the assumptions used to develop them are appropriate for the instruments and the survey methods used to collect the data.
- The survey methods used to collect the data are appropriate for the media and types of radiation being measured.
- The custody of samples collected for laboratory analysis is tracked from the point of collection until final results are obtained.

Where one or more of the above criteria are not met, the discrepancy will be reviewed, and the reasons for acceptability of the data or the corrective actions taken to restore data acceptability will be documented.

9.210.2 NUMERICAL DATA REVIEW

Contiguous static measurements and volumetric sample results will be compared to the remediation goals. Statistical quantities (range, median, mean, and standard deviation) will be calculated. The presence and significance of outliers in the collected data sets will be assessed.

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Statistical analyses will be performed to identify trends, groupings, and outliers in the data population.

9.3.10.3 **GRAPHICAL DATA REVIEW**

Survey data will be graphed to identify patterns, relationships, or potential anomalies in the data that might go unnoticed using purely numerical methods. Multiple methods will be used to reveal characteristics of the data distribution that may not be apparent with other methods.

Graphical methods may include, but are not limited to, a posting plot, box-and-whisker plot, frequency (or histogram) plot, and/or cumulative distribution diagram constructed for each dataset as described below. Other statistical tools to be used include distribution analysis, normal probability plot, and comparison to material-specific background, if appropriate.

9.3.110.3.1 **Posting Plot**

A posting plot is used to identify spatial patterns in the data. A posting plot is simply a map of the survey unit with the data values entered at the measurement locations. The posting plot can reveal spatial inhomogeneities in the survey unit such as patches of elevated radioactivity or groupings of measurements that exceed the release criteria. It can also reveal spatial trends in data that may be due to inhomogeneities in the survey unit background material.

9.3.210.3.2 **Box-and-Whisker Plot**

A box-and-whisker plot is used to provide insight into the location, shape, and spread of the data. The bottom and top of the box represent the first and third quartiles, and the line inside the box represents the second quartile (the median) of the respective dataset. The ends of the whiskers represent the minimum and maximum values of the data still within 1.5 times the interquartile range (i.e., the difference between the first and third quartiles). Maximum or minimum values outside that range are shown as outliers. Where there is more than one outlier, only the maximum or minimum value is shown.

9.3.310.3.3 **Frequency Plot**

A frequency plot is used to examine the general shape of the data distribution. Such plots may reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution. When the data distribution is highly skewed, it may be result of dissimilar populations or, often, because there are a few areas of elevated radioactivity. The presence of

two peaks in the data may indicate the existence of isolated areas of elevated radioactivity or a mixture of background distributions due to different soil types, construction materials, etc.

9.3.4.10.3.4 Cumulative Frequency Plot

A cumulative frequency diagram is used to provide information on the general shape of the data distribution and to identify data-points that do not follow the general data distribution. The diagram is constructed assuming normally distributed data, which, when plotted, form a straight line. A sharp bend in the plotted data indicates the possibility of multiple distributions, and outliers show up as individual points separate from the rest of the distribution. Such anomalies indicate dissimilarity in the data, as would be present with radioactive contamination.

9.4 STATISTICAL TEST

~~The Sign or the WRS statistical test will be applied to survey [XE "Final survey"] data sets where one or more measurements exceed the remediation goals [XE "DCGL"]. The statistical test is based on the hypothesis that the level of residual radioactivity in the survey unit exceeds the remediation goal. There must be sufficient survey data at or below the remediation goal to reject this statistical hypothesis and to conclude the survey unit meets the remediation goals [XE "Dose"]. Data sufficiency is a function of the number of data points, the variability in the data, the type of statistical test used, and decision error rates established in the survey.~~

~~The Sign test and the WRS test are non-parametric tests. The basic distinction between parametric and non-parametric statistical tests is that the parametric tests use specific assumptions about the probability distributions of the measurement data. The most commonly made assumption is that the data fit a normal distribution. A non-parametric test does not assume normal data distribution. It uses fewer assumptions than a parametric test, and consequently requires less information to verify these assumptions and is less vulnerable to being found incorrect when these assumptions are violated. That is, the correct decision is more likely made about whether or not the survey data mean exceeds the remediation goal [XE "DCGL"], even when the data come from a skewed distribution.~~

~~The Sign test and WRS test assume the data are independent random measurements, and that the data are statistically independent or that there are no trends in the data. The WRS test also~~

assumes the data are in a symmetric, but not necessarily normal, distribution and that the reference area and survey unit distributions are the same except for a possible shift in the mean. Both statistical tests are tests of the median. The parameter of interest, though, is the mean. If the assumption of symmetry is valid, then the median and the mean are effectively equal, and the tests also are tests of the mean. If the assumption of symmetry is violated, then the non-parametric tests of the median approximately test the mean.

The statistical test does not need to be performed when the survey data clearly show that the survey unit meets the remediation goals, such as when every measurement in the survey unit is less than or equal to the remediation goals.

9.4.1 Sign Test

The one-sample Sign statistical test is used if the radionuclide of concern is not present in background and radionuclide-specific measurements are made. The Sign test may also be used if one or more radionuclides are present in background at such small fractions of the remediation goal [XE "DCGL"] as to be considered insignificant. In this case, background concentrations of the radionuclides are included with the residual radioactivity (in other words, the entire amount is attributed to Navy legacy operations). Thus, the total concentration of the radionuclides are compared to the remediation goal [XE "Dose"]. This option is only used if it is expected that ignoring the background concentration does not affect the outcome of the statistical test. The advantage of ignoring a small background concentration is that no reference area is needed.

The Sign test is applied as follows:

- ◆ List the survey unit measurements, x_i , $i = 1, 2, 3, \dots, n$; where n = the number of measurements.
- ◆ Subtract x_i from the remediation goal [XE "DCGL"] to obtain the difference (remediation goal [XE "DCGL"] - x_i , $i = 1, 2, 3, \dots, n$).
- ◆ Discard differences where the value is exactly zero and reduce n by the number of such zero measurements.
- ◆ Count the number of positive differences. The result is the test statistic S . Note that a positive difference corresponds to a measurement below the remediation goal [XE "DCGL"].

- Compare the value of S^+ to the critical values in MARSSIM Table L.3. The table columns equate to the false positive decision error rate, α . The value of α is the probability of passing a survey unit which actually fails to meet the remediation goals [XE “Dose”], which is obtained from the survey design (the initial value is 0.05—see Section 8.8.1). If S^+ is greater than the critical value for the false positive decision error rate given in the table, the survey unit meets the remediation goals. If S^+ is less than the critical value, the survey unit fails to meet the remediation goals.

9.4.2 WRS Test

The two-sample WRS statistical test is used when the radionuclide of concern appears in background or if measurements are used that are not radionuclide-specific. Because gross activity measurements are not radionuclide-specific, they must be performed for both the survey unit being evaluated by the WRS test and for the corresponding reference area.

The WRS test is applied as follows:

- Adjust the reference area measurements by adding the remediation goal [XE “DCGL”] to each reference area measurement, X_i ($X_i + \text{remediation goal}$).
- Sum the number of adjusted reference area measurements, m , and the number of survey unit measurements, n , to obtain N ($N = m + n$).
- Pool and rank the measurements in order of increasing size from 1 to N . If several measurements have the same value, they are all assigned the average rank of that group of measurements.
- Sum the ranks of the adjusted reference area measurements to obtain W_r .
- Calculate the critical value using MARSSIM Equation L.1¹:

Equation 9-1

[EMBED Equation.2]

where z is the $(1 - \alpha)$ percentile of a standard normal distribution. Values for z can be found in MARSSIM Table 5.2. The value of α is obtained from the survey design (the initial value is 0.05—see Section 8.8.1). Where m and n are less than 20, the critical value is given in MARSSIM Table L.4.

- Compare the value of W_r with the critical value calculated above. If W_r is greater than the critical value, the survey unit meets the remediation goal [XE “Dose”]. If W_r is less than the critical value, the survey unit fails to meet the remediation goal.

¹ MARSSIM Equation L.2 is used if there are several measurements that have the same values.

9.4.3 Data Conclusions

The results of the statistical test allow one of two conclusions to be drawn. The first conclusion is the survey unit meets the remediation goals [XE "Dose"]. The statistical test results provide statistically sufficient evidence that the average residual radioactivity in the survey unit does not exceed the remediation goals.

The second conclusion that can be drawn is the survey unit fails to meet the remediation goals [XE "Dose"]. The statistical test results do not provide statistically sufficient evidence that the average residual radioactivity in the survey unit does not exceed the remediation goals. Possible reasons the survey unit may fail [XE "Dose"] are: 1) it is in fact true, or 2) it is a random statistical fluctuation. If it appears that the failure may be due to statistical fluctuations, the survey unit may be resurveyed and another set of measurements collected for statistical analysis. A larger number of measurements increases the probability of passing if the survey unit actually meets the remediation goal. If it appears that the failure was caused by the presence of residual radioactivity in excess of the remediation goals, the survey unit will be remediated and resurveyed.

9.5.10.4 DOSE AND RISK MODELING

Survey data will be used to calculate dose and risk to an average member of the critical group based on either the building occupancy scenario for Buildings 211 and 253, or the suburban resident scenario for the trenches excavated to remove the SSSD lines.

9.5.10.4.1 Building Occupancy Scenario

For Buildings 211 and 253, the computer modeling software RESRAD-BUILD for Windows, Version 3.5 (ANL, 2009) will be used based on a building occupancy scenario. The methodology and assumptions that will be used are found in Appendix I. The building used in the dose model is conceptualized as a single-room structure. The dose receptor is assumed to be a person standing on the floor in the center of the room. The room is assumed to be uniformly contaminated on the floor and lower walls (wall surfaces less than 2 m above the floor). No contamination is assumed on the upper walls or ceiling. The radioactive source is assumed to be the most limiting radionuclide for each type of particle emission (i.e., Ra-226 for alpha and Sr-90 for beta).

The dose model accounts for exposure to both fixed and removable thin-layer surface radioactivity via a series of six exposure pathways. The RESRAD-BUILD default parameters will be used with the exception of the removable fraction, which will be limited to 20 percent of the total surface radioactivity, as specified in Section 3.2.

9.5.210.42 **Suburban Resident Scenario**

For trenches excavated to remove the SSSD lines, the computer modeling software RESRAD-ONSITE for Windows, Version 7.2 (ANL, 2016) will be used based on a suburban resident scenario. The methodology and assumptions that will be used are found in Appendix J. The residential environment used in the dose model is conceptualized as a contaminated area of surface soil with a house on it. The dose receptor is assumed to be a person that lives in the house and spends time both indoors and outdoors, but does not ingest any water, meat, milk, or food from on-site sources. Existing land use and activity restrictions at HPNS prohibit the consumption of food grown on site. The radioactive source is assumed to be the net activity concentrations above background of the radionuclides of concern.

The dose model accounts for exposure to radioactivity via a series of three exposure pathways: external exposure, inhalation of dust, and ingestion of soil. The RESRAD-ONSITE default parameters will be used with the exception of the contaminated area and the distance of the length of the contaminated area parallel to the aquifer. Actual survey unit surface area values will be used.

~~10.011.0~~ SURVEY DATA REPORTING

Data will be reported to the Navy on a routine basis as it is generated and fieldwork elements are completed. A data package will be prepared for each building, excavated trench, and screened soil survey unit once remediation and survey activities are complete and survey and sampling data are assessed. The compiled data package will be submitted to the Navy for review and concurrence. The information in the compiled data packages will be summarized into an FSS report that documents the FSS performed. Lastly, a RACR will be prepared to document the removal/remediation actions performed consistent with the Parcel C ROD (Navy, 2010).

~~10.011.1~~ SURVEY UNIT DATA PACKAGES

A survey unit data package will be compiled for each survey unit once remediation and survey activities within the survey unit are complete and the survey and sampling data have been assessed. The data package contains sufficient information to demonstrate that the survey unit complies with the release criteria and is suitable for radiological release to unrestricted use. At a minimum, each data package will include:

- Survey unit description and physical “as-left” condition, including remaining M&E;
- Removal/remediation activities performed;
- Post-removal/remediation radiological survey and sampling data collected, including survey coverage, and type and number of measurements/samples; and
- Data assessment results, including summary of numerical/graphical data review, statistical test, and dose and risk modeling results; and
- Conclusion regarding survey unit compliance with release criteria and suitability for radiological release to unrestricted use.

SSSD-related (i.e., excavated trench) data packages will be based on of the *Survey Unit Project Report Abstract for the Sanitary Sewer and Storm Drain Removal Project, Hunters Point Shipyard, San Francisco, California* (TtEC, 2013). Building-related data packages will be based on an example survey unit data package format found in Appendix K. The presentation and content of the data package will be refined working with the Navy and other stakeholders. Data packages will be prepared as the fieldwork is completed and provided to the Navy for review and acceptance.

Data packages are designed as a stand-alone documents to allow independent review and verification of survey results. Once accepted by the Navy, they will be made available for review by other stakeholders as a courtesy on an information-only basis. Comments will be considered and incorporated on an informal basis. Formal stakeholder review still will occur with the FSS report.

~~10.2.11.2~~ **COMPLETION REPORTS**

The two completion reports – an FSS report and a RACR – will be prepared following the completion of the field work. A draft version of the FSS report and the RACR will be provided to the Navy and ~~BRAC Closure Team (BCT)~~ for review. A formal response to comments on the draft version of the report will be provided to the Navy and BCT members for review and approval prior to preparation and submittal of the final report versions.

~~10.2.11.2.1~~ **Final Status Survey Report**

A single FSS report will be prepared for Buildings 211 and 253 since the survey design, data collection, and data assessment methods used will be the same for both buildings. The report will summarize the survey activities performed, the data collected and the methods used to collect them, the survey results and statistical analysis, the dose and risk modeling performed, and the conclusions regarding compliance of the buildings with the release criteria and their suitability for radiological release to unrestricted use.

~~10.2.11.2.2~~ **Removal Action Completion Report**

Following completion of the FSS report, and concurrence from the RASO, BRAC, and the BCT, a RACR will be prepared to summarize the findings of the FSS, as well as to document the removal and remediation activities performed in preparation for the FSS. The RACR will present the conceptual site model; describe the nature and extent of radiological contamination encountered; provide a summary of residual risks following removal, remediation, and FSS; and provide sound justification for clean closure and radiological release to unrestricted use.

The RACR will include:

- Executive Summary;
- Site conditions and background;

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DRAFT Work Plan
Parcel C Buildings 211 and 253 Radiological Remediation
Hunters Point Naval Shipyard, San Francisco, California

- Description of field methods and procedures;
- Any variances from project plans with approved FCRs;
- Summary of work performed;
- Certification that work was performed;
- Removal/remedial activities;
- Air monitoring data, excavation chemical testing results, waste manifests;
- Demonstration of completion;
- References; and
- Applicable appendices.

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APPENDIX E
RADIONUCLIDES OF CONCERN

APPENDIX E

RADIONUCLIDES OF CONCERN

As identified in the HRA (NAVSEA, 2004), Buildings 211 and 253 are impacted by the following radionuclides of concern. Their use, natural presence, half-life, and mode of decay are taken from the *Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas* (ANL, 2007) and are discussed below.

Strontium-90

Sr-90 does not occur in nature, but is a product of nuclear fission. It is routinely encountered in the environment as a result of the historic practice of atmospheric testing of nuclear weapons. Sr-90 has a half-life of 29 years. Its mode of decay is by beta particle emission (average energy = 0.20 MeV), which transforms Sr-90 into Y-90. Y-90 has a half-life of 64 hours. Its mode of decay is by beta particle emission (average energy = 0.94 MeV), which transforms Y-90 into zirconium-90, which is a stable isotope. Due to the short half-life of Y-90, there are essentially two beta particle emissions with every atomic transformation of Sr-90.

Cesium-137

Cs-137 does not occur in nature, but is a product of nuclear fission. As with Sr-90, it is routinely encountered in the environment as a result of the historic practice of atmospheric testing of nuclear weapons. Cs-137 has a half-life of 30 years. Its mode of decay is by beta particle emission (average energy = 0.19 MeV), which transforms Cs-137 into barium-137, which is a stable isotope.

Radium-226

Ra-226 occurs in nature as a decay product of naturally occurring uranium. Ra-226 has a half-life of 1,600 years. The primary modes of decay for Ra-226 and its short half-life progeny are shown in Exhibit E-1. Due to the short half-lives of its progeny radon (Rn)-222, polonium (Po)-218, lead (Pb)-214, bismuth (Bi)-214, and Po-210, there are essentially four alpha particle and two beta particle emissions with every atomic transformation of Ra-226. However, because Rn-

222 is a noble gas, progeny contributions to detectable Ra-226 activity are reduced due to radon emanation from the surface being measured.

Exhibit E-1. Radioactive Properties of Ra-226 and its Short Half-Life Progeny

Radionuclide	Half-Life	Mode of Decay	Radiation Energy (MeV)	
			Alpha	Beta ^a
Ra-226	1,600 years	alpha	4.8	--
Rn-222	3.8 days	alpha	5.5	--
Po-218	3.1 minutes	alpha	6.0	--
Pb-214	27 minutes	beta	--	0.25
Bi-214	20 minutes	beta	--	0.66
Po-214	<0.01 seconds	alpha	7.7	--
Pb-210	22 years	beta	--	0.038

Note:

^a sum of radiation energies per disintegration

The decay chain of Ra-226 extends beyond Pb-210, though secular equilibrium has not yet been achieved due to the longer half-life of Pb-210 (22.3 years) relative to other Ra-226 progeny.

Alpha particle emission is used to detect Ra-226. The beta particles emitted by Pb-214 and Bi-214 could also be used to detect Ra-226, though no particular advantage is offered with beta particle detection over alpha particle detection.

Thorium-232

Th-232 occurs in nature as naturally occurring ~~thorium~~uranium. Th-232 has a half-life of 1.4×10^{10} years. The primary modes of decay of Th-232 and its progeny are shown in Exhibit E-2.

Due to the relatively short half-lives of its several progeny, there are essentially six alpha particle (due to branching) and four beta particle emissions (or more) with every atomic transformation of Th-232. However, because Rn-220 is a noble gas, progeny contributions to detectable Th-232 activity are reduced due to radon emanation from the surface being measured. Alpha particle emission is used to detect Th-232. The several beta particles emitted could also be used to detect Th-232, though no particular advantage is offered with beta particle detection over alpha particle detection.

Exhibit E-2. Radioactive Properties of Th-232 and its Progeny

Radionuclide	Half-Life	Mode of Decay	Radiation Energy (MeV)	
			Alpha	Beta ^a
Th-232	1.4 x 10 ¹⁰ years	alpha	4.0	
Ra-228	5.8 years	beta		0.017
Ac-228	6.1 hours	beta		0.48
Th-228	1.9 years	alpha	5.4	
Ra-224	3.7 days	alpha	5.7	
Rn-220	56 seconds	alpha	6.3	
Po-216	0.15 seconds	alpha	6.8	
Pb-212	11 hours	beta		0.18
Bi-212	61 minutes	alpha,beta	2.2	0.47
Po-212 (64%)	<0.001 seconds	alpha	8.8	
Tl-208 (36%)	3.1 minutes	beta		0.60

Note:

^a sum of radiation energies per disintegration

Plutonium-239

Pu-239 does not occur in nature, but is a transuranic product of nuclear fission (i.e., neutron capture by a uranium atom). It is not found in the environment except as the result of human activities involving fissionable material. Pu-239 has a half-life of 24,000 years. Its primary mode of decay is by alpha particle emission (5.1 MeV), which transforms Pu-239 into uranium (U)-235. U-235, with a half-life of 7.04 x 10⁸ years, does not contribute to the number of alpha particle emissions.

APPENDIX F

ALPHA/BETA MEASUREMENT DETECTABILITY

APPENDIX F

ALPHA/BETA MEASUREMENT DETECTABILITY

Measurements of radioactivity at environmental levels involve very small amounts of radioactivity. Measurement uncertainty often makes it difficult to distinguish such small amounts from zero. Therefore, measurement detectability, expressed as the smallest concentration of radioactivity that can be reliably distinguished from zero, becomes an important measurement characteristic.

The method most often used to make a detection decision about radioactivity involves the principles of statistical hypothesis testing. To “detect” the radioactivity requires a decision on the basis of the measurement data that the radioactivity is present. The detection decision involves a choice between the null hypothesis (H_0): there is no radioactivity present (above background), and the alternative hypothesis (H_a): there is radioactivity present (above background). In this context, a Type I error, α , is to conclude that radioactivity is present when it actually is not, and a Type II error, β , is to conclude that radioactivity is not present when it actually is. Both types of decision errors were set to 0.05 (5 percent).

When Background Counts Are High (greater than > 100)

When the background counts are high (> 100), traditional equations used to calculate the MDC, such as Equation F-1, used when the background count time (T_B) and sample count time (T_S) are not equal, work well. At lower background levels, such equations can produce a high rate of Type I errors. This means that too often a decision is made that there is radioactivity present when it actually is not.

Equation F-1

$$MDC = \frac{3 + 3.29 \sqrt{R_B T_S \left(1 + \frac{T_S}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100 \text{ cm}^2} T_S}$$

where:

- R_B = background count rate (counts per minute [cpm])
- T_B = background counting time (min)
- T_S = sample counting time (min)

ε_i	=	instrument efficiency (counts per particle)
ε_s	=	surface efficiency (particles per disintegration [dis])
W_A	=	active area of the detector window (cm ²)

When Background Counts Are Low (less than or equal to [\leq] 100)

When the background counts are low (≤ 100), the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP; DoD et al., 2004) reports that the Stapleton approximation appears to out-perform all of the other approximations reviewed (see MARLAP, page 20-47)². Equation 3 from Table 7.6 of the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME; DoD et al., 2009) uses the Stapleton approximation, assuming the Poisson model and $T_B \neq T_S$ ³. The minimum detectable number of counts, S_D , is defined as the number of counts that gives a specified probability, $1 - \beta$, of being too large to be compatible with the premise that there is no radioactivity present (Equation F-2).

Equation F-2

$$S_D = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4} \left(1 + \frac{T_S}{T_B}\right) + (Z_{1-\alpha} + Z_{1-\beta}) \sqrt{N_B \frac{T_S}{T_B} \left(1 + \frac{T_S}{T_B}\right)}$$

where:

S_D	=	minimum detectable number of counts (cnts)
α	=	type I decision error or false positive; (0.05)
β	=	type II decision error or false negative; (0.05)
$Z_{1-\alpha}$	=	(1 - α)-quantile of the standard normal distribution, or $Z_{0.95}$ (1.645)
$Z_{1-\beta}$	=	(1 - β)-quantile of the standard normal distribution, or $Z_{0.95}$ (1.645)
T_S	=	sample count time (min)
T_B	=	background count time (min)
N_B	=	background counts (cnts)

The MDC, in units of dpm/100 cm², may be calculated by converting the minimum detectable number of counts, S_D , to a concentration over a 100 cm² area using Equation F-3.

² MARSSIM and MARLAP are complementary documents providing guidance on radiological surveys and measurements. MARSSIM addresses field measurements and sample collection, while MARLAP addresses laboratory measurements and sample processing. Guidance on assessing measurements in these manuals may be applicable to both field and laboratory applications.

³ MARSAME is a supplement to MARSSIM, providing guidance on surveys of materials and equipment in addition to the surveys of real property (buildings and land areas) discussed in MARSSIM. As a supplement to MARSSIM, the guidance in MARSAME may be applicable to real property as well as materials and equipment.

Equation F-3

$$MDC = \frac{S_D}{\varepsilon \frac{W_A}{100 \text{ cm}^2} T_S}$$

where:

- S_D = minimum detectable number of counts
- ε = total efficiency (cnts/dis)
- W_A = active area of detector window (cm²)
- T_S = sample count time (min)

APPENDIX G
EXAMPLE SURVEY UNIT WORK PACKAGE

APPENDIX H

TECHNICAL BASIS FOR USE OF CONTIGUOUS STATIC MEASUREMENTS IN LIEU OF SCANNING

APPENDIX H

TECHNICAL BASIS FOR USE OF CONTIGUOUS STATIC MEASUREMENTS IN LIEU OF SCANNING

The following presents the technical basis for Gilbane's use of contiguous static measurements in lieu of scanning in MARSSIM applications where measurements of alpha total surface radioactivity are called for. Contiguous static measurements are neighboring measurements of surface radioactivity that share proximity in both space and time, i.e., they are collected spatially near one another and at about the same time, with each measurement performed at a discrete location for a fixed count time.

Background:

The process described in MARSSIM (DoD et al., 2000) relies on scanning to provide a qualitative level of confidence that no areas of elevated residual radioactivity (i.e., radioactivity above the action threshold) remain that may have been missed by static measurements collected from across a survey unit. The probability of detecting elevated residual radioactivity by scanning is affected not only by the sensitivity of the instrument, but also by the surveyor's technique (i.e., holding the detector a specific distance from the surface while moving it at a constant speed) and the surveyor's ability to interpret the counts registered by the instrument. The surveyor must decide whether the counts represent background or radioactivity in excess of background that should be investigated.

The detection of elevated residual radioactivity by scanning is particularly problematic for alpha radioactivity where the number of counts necessary to exceed the action threshold approaches background levels (where the expected instrument response is close to zero). Due to its random nature, radioactive decay is most easily measured by increasing the length of time over which the measurement is made. Consequently, the slower the scan speed, the higher the probability of detection. Beyond the cost consideration, however, the slower scan speed creates data quality issues as human reliability and randomness of radioactive decay become dominant variables.

The two questions become:

1. Can a surveyor scanning at a very slow scan speed for an extended period of time reliably and consistently detect areas of elevated residual radioactivity that may exist?

2. Will the random and spontaneous radioactive decay event occur during the time interval that the detector is over the location of the elevated residual radioactivity and thus alert the surveyor to the location?

Design Advantages

Gilbane designed its contiguous static measurement methodology to remove the uncertainty inherent in the scanning process – in particular the human factor considerations – and to provide the necessary assurance that surfaces are free of radioactive contamination. These and other advantages achieved by the design include:

- Data quality concerns that often surround scanning (i.e., reliance on a human surveyor with its associated uncertainties – scan speed, increased count response, probability of detection) are eliminated.
- While the effective scan coverage is the same, significantly lower detection levels can be achieved, providing assurance that any areas of radioactive contamination are identified.
- The opportunity to miss an area of elevated residual radioactivity during scanning is removed through the process of collecting contiguous static measurements over the entire scan coverage area.
- Since they are discrete measurements performed at finite locations, contiguous static measurements may be used to demonstrate compliance with the release criteria.
- While scanning normally does not result in captured data, contiguous static measurements are captured and available for both numerical and graphical analyses.

Instrumentation

Contiguous static measurements are made using an array of six Ludlum Model 43-37-1 821 cm² gas-flow proportional detectors coupled to a Ludlum Model 4612 12-channel counter. These commercially available “off-the-shelf” instruments were selected for use based on their reliable operation, detection sensitivity, operating characteristics, and performance in the field. They are industry-tested with proven reliability.

The Ludlum Model 43-37-1 detectors are mounted side-by-side lengthwise in a 3 x 2 configuration on a frame measuring approximately 58 cm by 136 cm. The dimensions of each detector are 15.9 cm wide by 64.1 cm in length. The frame orients the detectors relative to each other and the surface being measured. Each detector is independently spring-mounted within the frame so as to “float” free from the other five detectors. This allows each detector to conform to slight irregularities in the planar surface beneath it. A series of spacers around the edge of the

face of each detector maintain the detector window less than 1 cm from the surface. When the detector array is moved into position, the detectors are held in contact with the surface by pressure from their compressed mounting springs.

The detector array is connected to a Ludlum Model 4612 12-channel counter, which supplies an alpha and beta channel for each of the six detectors. The counter is connected to a laptop computer by which the operating parameters of each detector are controlled. Each detector has independent high voltage, threshold, and window settings. The Model 4612 counter is configured with a single host board and a slave board for each detector. The slave board powers the detector and sends the count data to the host board. The host board collects the counts from each slave board and communicates with the computer. The computer collects and displays the data and is used to start and stop each count. The Model 4612 counter software (vendor supplied) monitors the activity of the counter and allows the surveyor to control and log data from the individual detectors (Ludlum Measurements, Inc. [Ludlum], 2014). The software also allows the surveyor to modify the parameters of each slave board.

Detection Sensitivity

Exhibit G-1 illustrates typical performance characteristics of a Model 43-37-1 detector used to perform a 1-minute count (Ludlum, 2016). Acceptable levels of total surface radioactivity are usually in the range of 1,000 dpm/100 cm² or higher for beta radioactivity, and 100 dpm/100 cm² – and in some cases lower – for alpha radioactivity. MDC values significantly below those levels are readily achievable for both alpha and beta radioactivity.

Exhibit H-1. Ludlum Model 43-37-1 Detector Typical Performance Characteristics

Parameter	Alpha	Beta
Instrument background	7 cpm	1,400 cpm
Total efficiency (4π)	0.05 (5 percent)	0.13 (13 percent)
Count time	1 minute	1 minute
MDC	29 dpm/100 cm ²	121 dpm/100 cm ²

Measurement Methodology

The detector array is positioned against the floor or wall surface where the surface radioactivity measurements are to be obtained. As shown in Exhibit H-1, a 1-minute count time is sufficient

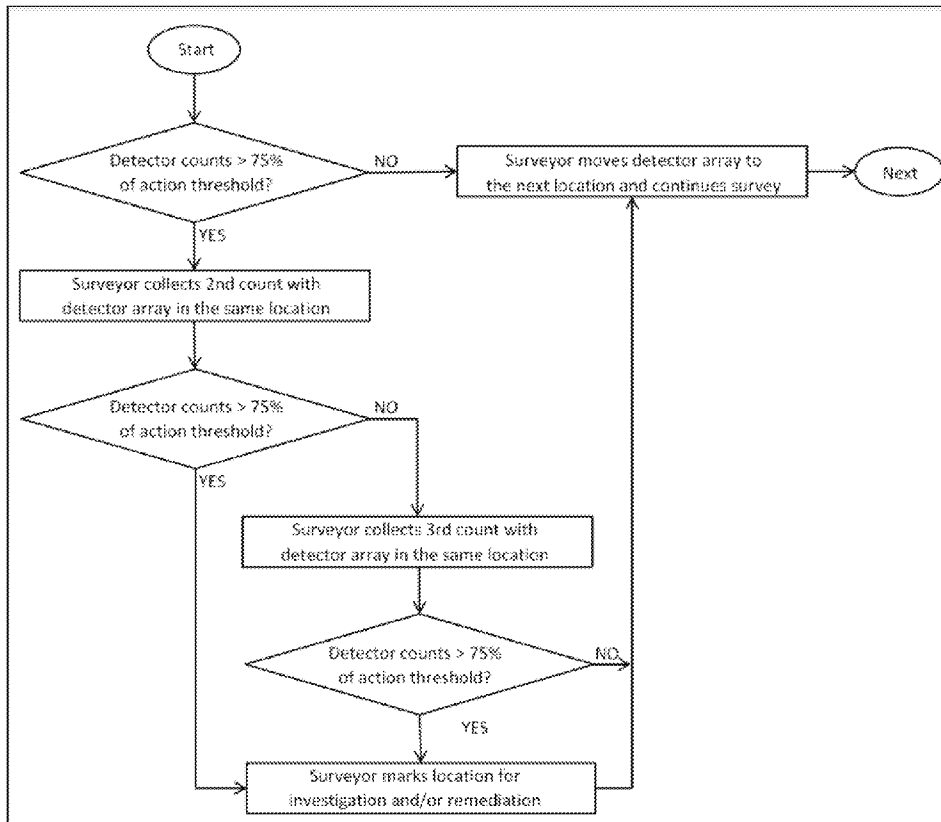
to produce an MDC less than one-half of most acceptable total surface contamination limits. The count is taken and logged in the computer. Twelve individual counts – two per detector (one alpha and one beta-gamma) – are captured along with a date/time stamp for each count. If any detector reports counts exceeding 75 percent of the action threshold, it is flagged and 2-out-of-3 logic is applied, as shown in Exhibit H-2.

Locations where the detector counts exceed 75 percent of the action threshold 2 of out 3 times are marked for further assessment and/or remediation. The detector array is moved to the next measurement location and the process repeated until contiguous static measurements have been collected across the entire scan coverage area.

Effective Scan Coverage

The detector array covers a surface area of approximately 1.0 m². However, approximately 40 percent of the surface area covered by the detector array is outside a detector window (i.e., active area). In other words, 60 percent of the surface area covered by the detector array is within the active area of a detector. So, taking measurements at a sequential spacing of one detector array-width would result in an effective scan coverage of 60 percent – insufficient for a Class 1 survey unit, which typically has a scan coverage requirement of 100 percent. To achieve 100 percent scan coverage, the detector array is moved to an offset position so that surface areas originally missed are now covered, as shown in Exhibit H-3, and a second count is performed. The process is then continued by moving the detector array over one array-width and repeating the two-step count process.

Exhibit H-2. Diagram Showing 2-Out-of-3 Logic



The scan coverage requirement for Class 2 and Class 3 survey units is typically much less than for a Class 1 survey unit. Since a scan coverage of 60 percent is provided by the detector array itself, a higher scan coverage is achieved by overlapping the detector array positions, as illustrated in Exhibit H-3. A lower scan coverage is achieved by increasing the spacing between detector array positions for each subsequent measurement.

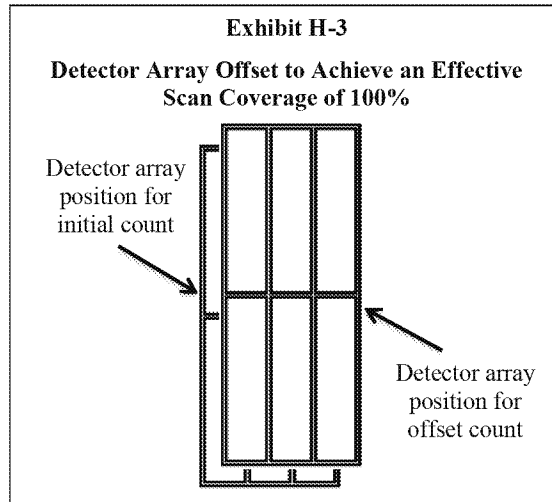
Small Area Coverage

A single Model 43-37-1 detector is used to perform contiguous static measurements in small or tight areas where the detector array cannot be used effectively (e.g., ledges, corners, irregularly shaped surfaces). The same measurement methodology is used, including the detector offset method where the scan coverage requirement is greater than 60 percent.

Hot Spot Detection

A common requirement for scanning is that it not only be capable of detecting distributed contamination over a 1-m² area or larger, but also be capable of detecting a hot spot (i.e., small area of localized contamination) over an area as small as 100 cm². A routine practice in MARSSIM applications is to limit the hot spot activity to three times the action threshold for distributed activity. For example, where the action threshold for alpha total surface radioactivity is 100 dpm/100 cm², the scanning process must be able to detect a hot spot of 300 dpm over an area no larger than 100 cm².

A large-area detector such as the Model 43-37-1 cannot distinguish whether the counts are from radioactivity distributed over the entire active area of the detector or are localized over a smaller area. To determine whether the detector is capable of detecting a hot spot, the counts are assumed to be from a single 100 cm² area rather than distributed across the entire active area of the detector. The hot spot activity divided by the detector active area and multiplied by 100 gives the equivalent activity that the detector must be able to detect. For example, a Model 43-37-1 detector must be able to detect alpha activity equivalent to 37 dpm/100 cm² to assure that a 100 cm² hot spot of 300 dpm alpha will be detected. The alpha MDC value from Exhibit H-1 shows that this level of hot spot detection is achievable with a 1-minute count time.



Demonstration of Compliance with Release Criteria

The MARSSIM process relies on a statistically significant number of static measurements collected from both random and systematically spaced locations to demonstrate compliance with the release criteria. This results in 10, 20, or even 30 static measurement locations per survey unit. The advantage of contiguous static measurements is that they can be used not only in lieu of scanning, but also as static measurements to demonstrate compliance with the release criteria since they are discrete measurements performed at finite locations.

The detector array yields measurement results for a total of six equivalent static measurement locations – one per detector – over each approximate 1.0 m² surface area. Assuming 100 percent scan coverage of a 100 m² Class 1 survey unit, for example, measurement results from a total of 1,200 equivalent static measurement locations would be generated (see the detector offset method illustrated in Exhibit G-3). This number of static measurements is 40 to 100 times more than the number of static measurements called for by MARSSIM. Of course, the number would be much lower for a Class 2 or Class 3 survey unit; however, it still would be several times more than the number of traditional static measurements collected per survey unit.

Numerical and Graphical Data Analysis

Contiguous static measurements also are available for numerical and statistical analyses to identify trends, groupings, and outliers in the data population. Contiguous static measurement data may be graphed to identify patterns, relationships, or potential anomalies in the data that might go unnoticed using purely numerical methods. Since the detector counts are performed at discrete locations, each measurement can be assigned XY coordinates for purposes of mapping coverage or using graphical analytical techniques such as posting plots or contour maps. Where this is done, the measurements are assigned XY coordinates corresponding to the center of the detector, as illustrated in Exhibit H-4, relative to a selected starting point (0,0) on the surface.

Summary

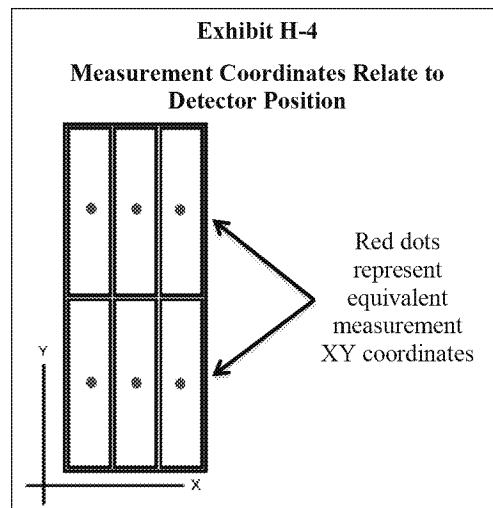
Contiguous static measurements provide not only equivalent and effective scan coverage when performed in lieu of scanning, but also form a robust dataset both in quantity and quality, which

decision-makers can use to make sound decisions regarding the presence or absence of radioactive contamination.

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APPENDIX I

DOSE AND RISK MODELING USING THE BUILDING OCCUPANCY SCENARIO

APPENDIX I

DOSE AND RISK MODELING USING THE BUILDING OCCUPANCY SCENARIO

The computer modeling software RESRAD-BUILD for Windows, Version 3.5 (Argonne National Laboratory [ANL], 2009), will be used to calculate a hypothetical dose and risk to members of the general public based on a building occupancy scenario.

Radiological Exposure Model

RESRAD-BUILD is a pathway analysis model developed to evaluate the potential radiological dose incurred by an individual in a building contaminated with radioactive material. The radioactive material within the building can be released to the indoor air by mechanisms such as diffusion (radon gas), mechanical removal (decontamination activities), or erosion (removable surface contamination). The air quality model in RESRAD-BUILD considers transport of radioactive dust particulates due to air exchange, deposition and re-suspension, and radioactive decay and ingrowth.

Exposure Scenario

The building occupancy scenario accounts for exposure to both fixed and removable thin-layer surface radioactivity. The scenario assumes that individuals occupy the building in a passive manner without deliberately disturbing the residual radioactivity on building surfaces. However, it also assumes the uncontrolled release of contaminants into the air as a result of normal use (e.g., cleaning the building, washing the walls, vacuuming the floors, etc.). Occupancy of the building is assumed to begin immediately after the building has been radiologically cleared for unrestricted use. The exposure duration is assumed to be a calendar year (365 days).

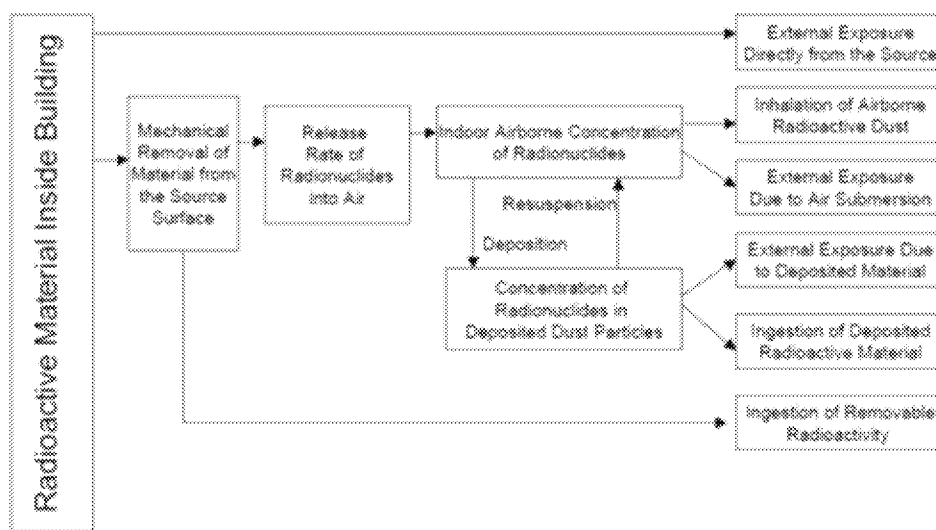
Critical Group

For the building occupancy scenario, the critical group is the building occupants who work in the building. The exposed occupants are the dose receptors, who can be office workers, residents, industrial workers, building visitors, or any individual spending time inside the contaminated building.

Exposure Pathways

The RESRAD-BUILD code models seven exposure pathways: (1) external exposure directly from the source, (2) external exposure to materials deposited on the floor, (3) external exposure due to air submersion, (4) inhalation of airborne radioactive particulates, (5) inadvertent ingestion of radioactive material directly from the source, and (6) ingestion of materials deposited on the surfaces of the room. These exposure pathways are illustrated on Exhibit I-1. The seventh exposure pathway - inhalation of aerosol indoor radon progeny – is not used.

Exhibit I-1. Exposure Pathways



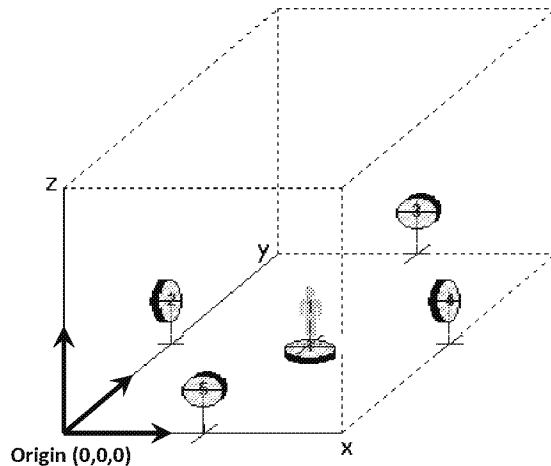
(Source: modified Figure 3.1, *User's Manual for RESRAD-BUILD Version 3.0* [ANL, 2003])

The first three pathways result in external exposure and the last four result in internal exposure. In RESRAD-BUILD, the external radiation doses are evaluated as effective dose equivalent, and the internal exposure is evaluated as committed effective dose equivalent. The conversion to effective dose equivalent weights the internal and external exposures such that their biological effect on the body can be summed. The total radiation dose, which is the sum of the external and internal doses, is then expressed as the total effective dose equivalent. The dose conversion factors used for inhalation, ingestion, and external exposures are discussed in detail in Appendixes D, E, and F, respectively, of the *User's Manual for RESRAD-BUILD Version 3.0* (ANL, 2003).

Building Description

The building used in the dose model is conceptualized as a single-room structure 6 m wide by 6 m long by 2.5 m high. A coordinate system used in RESRAD-BUILD defines the location of the radioactive sources and the dose receptor (building occupant) inside the room. Exhibit I-2 shows the point of origin located at the bottom left corner, with the x-axis measuring the horizontal distance to the right of the origin and coinciding with the bottom edge of the room; the y-axis being perpendicular into the room; and the z-axis measuring the vertical distance and coinciding with the left edge of the room.

Exhibit I-2. Dose Receptor Position Relative to Radioactive Sources



The dose receptor is assumed to be a person standing on the floor in the center of the room. The receptor location is at the midpoint of the person, i.e., 1 m above the floor. A coordinate system used in RESRAD-BUILD defines the location of the radioactive sources and the dose receptor (building occupant) inside the room. Exhibit I-2 illustrates the dose receptor location in the center of the single-room structure. The location of the dose receptor is a critical factor for calculation of the external dose. The air quality model in RESRAD-BUILD assumes that the air is homogeneously mixed in the room. Therefore, the other pathways are not affected by the location of the dose receptor.

The room is assumed to be uniformly contaminated on the floor and lower walls (wall surfaces less than 2 m above the floor). No contamination is assumed on the upper walls or ceiling. The floor and the four lower wall surfaces are each modeled as a distinct finite plane source, for a total of 5 sources. Each radioactive source is defined by its location, based on the coordinates of its center, according to the system of coordinates used for the room, its area, and the direction of the source. The contaminated area is defined as the surface area of the source facing the open air. Source direction is defined as the vector perpendicular to the exposed area, which is coincident with one of the axes (x, y, or z).

Radioactive Source Description

The radioactive source is assumed to be composed of the radionuclides of concern with the most limiting release criterion for each type of particle emission (i.e., Ra-226 for alpha and Sr-90 for beta). The concentrations are based on actual measurements of alpha and beta total surface radioactivity (fixed plus removable) collected from throughout the building. Both Ra-226 and Sr-90 are assumed to be in equilibrium with their progeny.

Radioactive Source Transport

Mechanical removal and erosion of the source material, when the surface is exposed to open air, will result in the transport of part of its mass directly into the indoor air environment, resulting in airborne contaminants. Because of the air exchange process, the airborne particulates are loaded into the indoor air of the room and homogeneously mixed.

Modeling Parameters

Exhibit I-3 lists the parameters used in the building occupancy scenario that are scenario-specific. Only those parameters different from RESRAD-BUILD defaults are listed. Other parameters remain at default values. It is assumed that for the building occupancy scenario, contamination is only on the surface. Detailed descriptions of parameters and their distributions are given in Appendix J of the *User's Manual for RESRAD-BUILD Version 3.0* (ANL, 2003).

Exhibit I-3. Scenario-Specific Dose Modeling Parameters

Parameter	RESRAD-BUILD Default Value	Scenario-Specific Value
Receptor location (m)	1,1,1	3,3,1
Source type	volume	area
Source geometry	circular	rectangular
Number of sources	1	5
Dimension of source(s) (m ²)	36	36 (floor), 48 (walls)
Removable fraction (dimensionless)	0.5	0.2

APPENDIX J

DOSE AND RISK MODELING USING THE SUBURBAN RESIDENT SCENARIO

APPENDIX J

DOSE AND RISK MODELING USING THE SUBURBAN RESIDENT SCENARIO

The computer modeling software RESRAD-ONSITE for Windows, Version 7.2 (Argonne National Laboratory [ANL], 2016), will be used to calculate a hypothetical dose and risk to members of the general public based on a suburban resident scenario.

Radiological Exposure Model

RESRAD-ONSITE is a pathway analysis model developed to evaluate the potential radiological dose incurred by an individual in an environment contaminated with radioactive material. The residential environment used in the dose model is conceptualized as a contaminated area of surface soil with a house on it. The model considers the transport of radioactive dust particulates due to re-suspension and radioactive decay and ingrowth.

Exposure Scenario

The suburban resident scenario accounts for exposure to radioactivity via a series of three exposure pathways: external exposure, inhalation of dust, and ingestion of soil. The scenario assumes that a person lives in the house and spends time both indoors and outdoors, but does not ingest any water, meat, milk, or food from on-site sources. Existing land use and activity restrictions at HPNS prohibit the consumption of food grown on site (Navy, 2010).

Critical Group

For the suburban resident scenario, the critical group is the permanent residents who live in the house on the contaminated soil and spend time both indoors and outdoors. The exposed occupants are the dose receptors.

Exposure Pathways

The RESRAD-ONSITE code models three exposure pathways: (1) external exposure directly from the contaminated soil, (2) inhalation of dust, and (3) ingestion of soil. The first pathway results in external exposure and the last two result in internal exposure. In RESRAD-BUILD, the external radiation doses are evaluated as effective dose equivalent, and the internal exposure

is evaluated as committed effective dose equivalent. The conversion to effective dose equivalent weights the internal and external exposures such that their biological effect on the body can be summed. The total radiation dose, which is the sum of the external and internal doses, is then expressed as the total effective dose equivalent. The dose conversion factors used for inhalation, ingestion, and external radiation exposures are discussed in detail in Appendixes A through J of the *User's Manual for RESRAD Version 6.0* (ANL, 2001).

Radioactive Source Description

The radioactive source is assumed to be composed of the radionuclides of concern at concentrations above background. The concentrations are based on actual measurements of radioactivity in the soil.

Radioactive Source Transport

Soil particles that become airborne by re-suspension are transported to a human exposure location where they are inhaled. External exposure and ingestion do not rely on source transport in the environment.

Modeling Parameters

Scenario parameters and default parameter values used for the RESRAD-ONSITE code are presented in Appendixes A through J of the *User's Manual for RESRAD Version 6.0* (ANL, 2001). The parameter values are kept at the RESRAD-ONSITE defaults for the suburban resident scenario, with the single exception of the contaminated area. The actual survey unit surface area value will be used.

APPENDIX K
EXAMPLE SURVEY UNIT DATA PACKAGE

APPENDIX L
RESPONSES TO COMMENTS